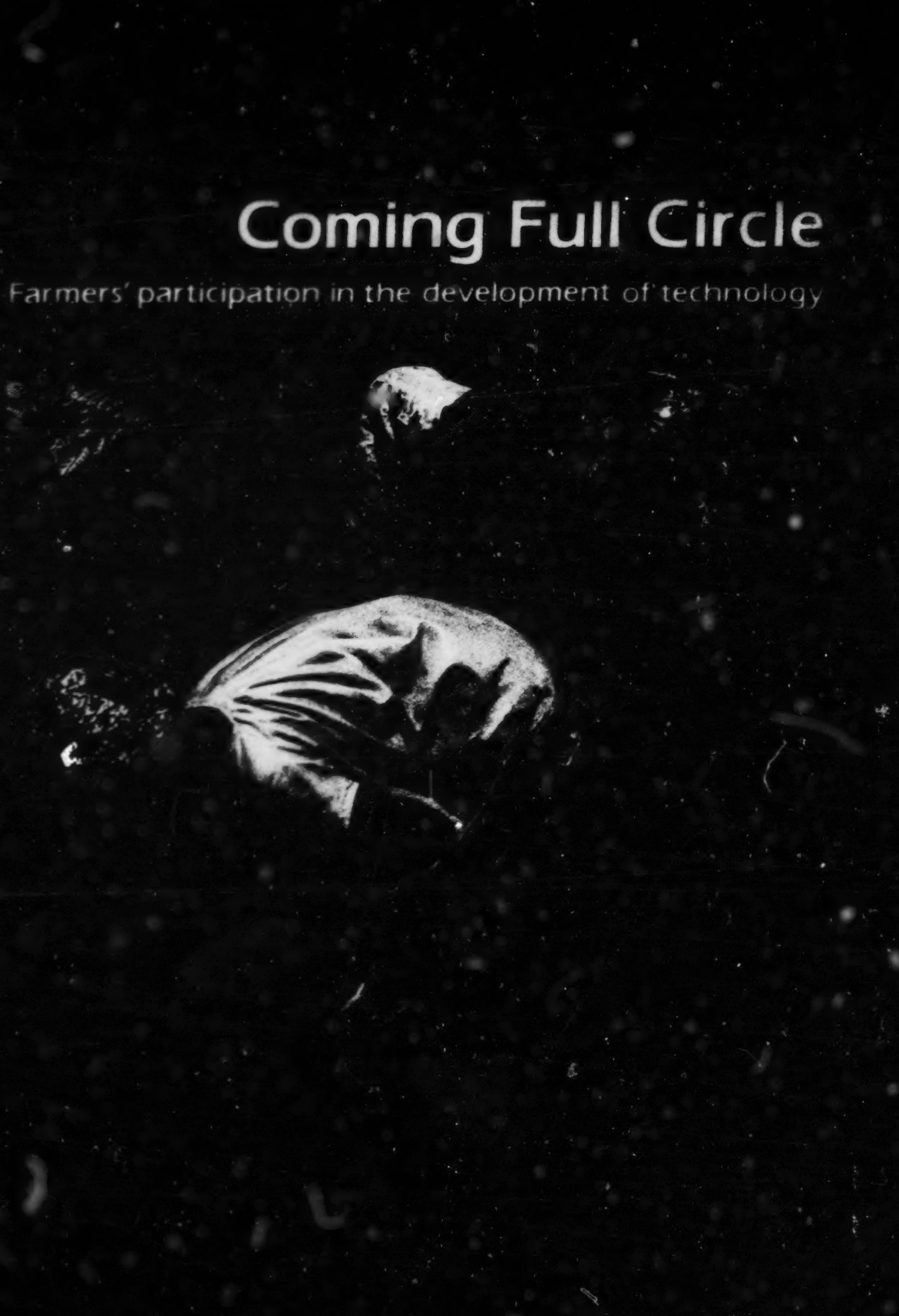
Coming Full Circle

Farmers' participation in the development of technology



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Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa, Canada

Mation, P.
Cantrell, R.
King, D.
Benoit-Cattin, M.

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Coming full circle: farmers' participation in the development of technology

Abstract

Involving farmers in identifying the constraints to rural agriculture and in designing measures to alleviate them is the subject of this publication, which resulted from a meeting, held in Ouagadougou, Upper Volta, 20 - 25 September 1983. Agronomists, economists, anthropologists, and others seeking to get the most from research efforts discussed the pitfalls of assembling packages that are sound technically but have some essential flaw because the developers have overlooked some crucial constraint at the farm level. The subject is one that is receiving much attention currently as agriculture in developing countries has failed to net major increases in production despite thousands of dollars invested in research and optimistic claims that improved varieties, techniques, equipment, etc. have been developed. The gaps between results on research stations and those on farms in the Third World have prompted some researchers to view the farmers' conditions as the real laboratories. Why, how, where, and when to get farmers involved in research are the focus of this document, and the degree to which researchers and the agencies they represent have been able to listen and work with their new partners varies, as is clear from the 11 papers and the commentary that follows them.

Résumé

La participation des paysans à l'identification des problèmes agronomiques et à la recherche de leurs solutions est le sujet de cette brochure qui rapporte les états d'un séminaire tenu à Ouagadougou (Haute-Volta) du 20 au 25 septembre 1983. Afin de mieux exploiter les résultats des recherches, des agronomes, des économistes, des anthropologues et d'autres personnes intéressées ont discuté du danger de préparer des blocs agronomiques, solides sur le plan technique, mais possédant des vices fondamentaux, les développeurs n'ayant pas pris en compte certains obstacles critiques au niveau des fermes. Ce thème est largement débattu aujourd'hui alors que la production agricole stagne dans les pays moins avancés malgré l'injection de milliers de dollars dans la recherche et les espoirs mis dans la création de variétés, techniques et équipement améliorés. La différence entre les résultats obtenus dans les stations de recherche et ceux recueillis sur les fermes ont conduit des chercheurs à reconnaître que la ferme même constituait le vrai laboratoire. Le thème principal de cet ouvrage qui se dégage des onze communications présentées et des commentaires qui suivent, est donc de déterminer quand, où, comment et pourquoi les fermiers doivent participer à la recherche et aussi, jusqu'à quel point les chercheurs (et les organismes qu'ils représentent) ont su être à l'écoute des paysans et travailler avec eux.

Resumen

La participación de los agricultores en la identificación de las limitaciones a la agricultura rural y en el diseño de medidas para superarlas es el tema de esta publicación que resultó de una reunión celebrada en Ouagadougou, Alto Volta, del 20 al 25 de septiembre de 1983. Agrónomos, economistas, antropólogos y otros interesados en obtener lo mejor de los esfuerzos investigativos, discutieron los problemas de producir paquetes técnicamente válidos que no obstante presentan fallas básicas porque sus diseñadores han perdido de vista alguna limitación crucial a nivel de la finca. El tema recibe actualmente mucha atención debido a que la agricultura de los países en desarrollo no ha podido aumentar la producción pese a los miles de dólares invertidos en la investigación y a las optimistas voces que proclaman haber desarrollado variedades, técnicas, equipo y otros elementos mejorados. La brecha entre los resultados de las estaciones de investigación y aquellos de las fincas del Tercer Mundo han hecho que algunos investigadores consideren las condiciones de los agricultores como los verdaderos laboratorios. Por qué, cómo, dónde y cuándo involucrar a los agricultores en la investigación es el tema central de este documento, y el grado en que los investigadores (y los organismos que representan) han podido escuchar y trabajar con sus nuevos socios varía como lo demuestran los 11 trabajos del libro y el comentario final que los sigue.

IDRC-189e

Farmers' participation in the development of technology

COMING FULL CIRCLE

Editors: Peter Matlon, Ronald Cantrell, David King, and Michel Benoit-Cattin

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Foreword

Agricultural research institutions now generally agree that technologies intended for small farmers should be identified, designed, and evaluated within the context of the farming systems practiced by farmers themselves. The value of farmer participation in such research is also widely recognized, although the degree to which farmer involvement is encouraged and effectively used varies. Examples of direct and creative collaboration between farmers and researchers do exist, but these are often not widely known and, as such, are of limited value for research teams elsewhere who are seeking greater and more efficient modes of farmer participation.

In 1980, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) received funding by the International Development Research Centre (IDRC) to initiate a broad program of socioeconomic research at the farmer and village level in specific agroclimatic zones of Upper Volta and Niger. The economic and anthropological research subsequently undertaken has a principal objective to work directly with farmers to diagnose their production problems and design appropriate solutions. The research has complemented ICRISAT technical programs by guiding development toward genetic materials and production systems adapted to farmers' conditions.

After their own fieldwork, the ICRISAT research team believed it would be valuable to review methods of on-farm technical research in a broad forum of agricultural and social scientists to exchange views and experiences. With this goal, ICRISAT and IDRC, together with the Semi-Arid Food Grains Research and Development (SAFGRAD) Project of the Organization of African Unity and the Institut de recherches agronomiques tropicales et des cultures vivrières (IRAT), organized a workshop on farmers' participation in the development and evaluation of technology, which was held in Ouagadougou, Upper Volta, 20–25 September 1983.

The more than 50 researchers who attended the workshop (Appendix) came from 20 countries within and outside Africa, represented technical and social-science disciplines, and included scholars trained in French and North American traditions of farming-systems research, with diverse views and experiences.

This volume accurately reflects the diversity of perspectives represented. It contains the papers presented at the meeting and written commentary prepared by discussants. The contributions address the farmers' and researchers' role in the description and diagnosis of the production environment and in the design, evaluation, and modification of technology. Dr René Tourte, Head of the farming-systems division, IRAT, provides a historical overview, which he presented in his keynote address.

In reviewing this volume, the reader will note that, despite the diversity of environments in which the various authors have worked, there is a general consensus on the fundamental principles of on-farm research and a convergence of methods. The degree to which direct and creative farmer participation has been achieved in the research programs is uneven, but we feel that this represents the fact that methods to involve farmers in technical research and evaluation are still evolving. The potential benefits of more complete involvement are considerable, but the practical problems are also considerable, demanding imagination and cultural sensitivity. We hope that this volume helps to improve the understanding of such problems and suggests possible directions for improved approaches.

We would like to thank the chairpersons for the plenary and discussion sessions who provided summaries from which information was taken for the introductions to the sections of this volume. Other information was drawn from the introductory sections of the papers submitted, which were pared accordingly.

Thanks also go to the Farming Systems Unit of Purdue University, SAFGRAD (represented on the editorial committee by Ronald Cantrell), and IRAT (Michel Benoit-Cattin) for their financial and logistical support for the meeting and this publication.

Peter Matlon
Economics Program, ICRISAT
and
David King
Social Sciences Division, IDRC

Introduction

R. Tourte, *Institut de recherches agronomiques tropicales et des cultures vivrières, Groupement d'études et recherches pour le développement de l'agronomie tropicale, Montpellier, France*

That farmers should participate in developing and evaluating technology for their own use is so evident that it has generally been ignored. In the past and still today, few efforts to help farmers have been designed with their participation.

This book aims to help correct this error — once again, unfortunately, without the farmers.

Saying that dialogue between researchers and farmers is essential implies that the two sides have something to say to each other and proposals to exchange so that they build mutual trust. What farmers can bring to the dialogue is a wealth of knowledge and skills to deal with the environment's harsh constraints: the true value of these assets must be recognized and understood. The researchers' contribution is innovation and resources, which provide the means to be taken seriously and the freedom to move away from the beaten path of traditional technologies.

Clearly, research to design a technology for farmers, who have multifaceted lives and constraints, must be developed by multidisciplinary teams. This assumes a commitment by all research disciplines to work together on the same problems, on the same scale, and with the same agenda. Moreover, researchers have no monopoly on discovery. Not only farmers but also extension and development personnel have valuable knowledge about rural societies and must be constantly associated with research efforts.

Brief background

The concept is not new. Over the years, many researchers and development workers have attempted to bring their work objectives and activities more in line with farmers' needs. Their efforts, however, have often been uncoordinated, if not contradictory.

In West Africa, attempts to establish dialogue between the partners in agricultural development gained impetus in the 1960s. Agronomists, biologists, and agricultural economists wanted to put "improved" technologies from research stations to the test in the reality of local environments.

Briefly and without nostalgia, I would like to recount the major steps on the road from the station to the farmer's field. In my view, there were five:

- Decentralizing the research structures and efforts: national centres

began to open regional stations, then subregional support points, and local outposts. A number of developing countries have now become dotted with simple, decentralized research structures. The aim was to foster personal and direct relations with local social groups. This first step brought about farmer-cooperators, test plots, demonstration fields, reference farmers, and so on.

- Building knowledge of the real environment: having met the agricultural producer — the farmer — researchers wanted to know more: the potential user's physical and economic environment. This step led to successful screening and selection of technologies for a particular environment.
- Enriching the technical message: researchers then enriched their proposals by going beyond single innovations and producing coherent technical "packages" of related innovations; testing these packages in the real environment to detect limiting factors such as work time, variations in farming practices, transportation problems, and crop processing; following up to ensure that unforeseen problems such as soil degradation, weed proliferation, and new pests, didn't emerge; and tailoring their experimental methods to local technical constraints. About 1965, some researchers took a fourth step.
- Refocusing objectives based on production conditions: researchers gradually found that when they had done their best to ensure that innovations (varieties, manuring, techniques) were valid, consistent, and well promoted by extension personnel, these innovations were sometimes rejected and sometimes widely accepted in a short time. Some crucial factors in the farmers' experience, methods of managing resources and tools, had been overlooked and were making the farmers unwilling or unable to adopt some technical proposals. Discovering those factors was recognized to be the work of multidisciplinary teams on site. The study would have to deal with the plot or herd; the farm; and the landscape or rural community, all of which affect the farmer daily. In other words, the farmer had to be at the centre of research. The farmer decides how to manage production to meet his or her objectives, taking into account natural resources and environmental constraints. This was a key step: researchers realized that, no matter how good their innovations were, they were not valid unless they fit into existing systems.
- Fashioning innovations to suit agrarian systems: the fifth, and current step, was taken shortly before 1970. In this step, researchers finally got into the farmers' fields. They moved not just their laboratories but themselves into the milieu. The research is closely linked with development, aimed at generating involvement and action by rural communities and districts (production groups, villages, groups of villages, and so on). Farmers negotiate with development personnel for the types of experiments they want and thus hold the real power to decide which techniques are the most appropriate. Researchers and extension personnel are involved in the effort on the same site, at the same scale, and at the same pace. Working together, gaining experience of each other's tasks, constraints, approaches to problem-solving, is the teaching method for all three groups of participants — farmers, extension personnel, and researchers. The

on the-job training gives them each a means to fine-tune their methods.

Thus have been born truly operational research projects — pilot projects, experimental development projects, and research-and-development projects. They have attracted the interest of financial institutions such as the World Bank, the United States Agency for International Development (AID), the European Development Fund (EDF), and the Caisse centrale de coopération économique (CCCE). Funding agencies see this new type of research as a route to development that is more self-motivated and, from a technical and even an economic point of view, more independent than previous efforts. The new projects have fostered great hopes; the challenge is to not betray them.

Intention vs action

Although respect for the farmer is increasingly regarded as a prerequisite for research and development, it is not always achieved. The reasons include:

- Deeply rooted prejudices or ideas: even the most egalitarian people sometimes have prejudices, believing that anything traditional is inherently inferior to anything modern, equating illiteracy with ignorance, and assuming that farmers are by nature conservative and opposed to innovation. Another, unfounded belief is that a project can be successful only if researchers (or, more often, extension personnel) introduce a series of simple innovations, separately and progressively. The advocates of this belief and practice say that farmers are not well-educated enough to cope with larger changes. They do not communicate their objectives and strategies to the farmer, much less negotiate them. Also, many people believe that involving selected farmers will result in spontaneous extension. In fact, carrying on dialogue with only a few farmers singles them out and isolates them from their social groups, which are often striving to prevent inequality. A related concept is that researchers should closely supervise participating farmers.
- An ignorance, often tragic, of what agricultural intervention should involve: the ignorance stems not from a lack of studies — these are often numerous, thorough, and rich — but rather from a shortcoming in the studies, which are often geared to analysis and knowledge, not change. It also stems from a difficulty in applying what has been learned. Many farmers are tired of having their needs and constraints repeatedly analyzed and not receiving any help in answering their questions.
- Institutional difficulties: the three-pronged approach involving research–development–production (RDP) simultaneously is still rare because of the burden of past practices, cumbersome structures, power struggles, and disputed jurisdiction. These institutional difficulties mean that not only the farmers must take risks but also the researchers and the extension personnel. Proposals are not enough: one must convince, take part, be committed. Researchers must scientifically prepare the conditions for the diffusion of new systems;

development workers must reconcile the desirable and the possible. When these two groups have adequately done their jobs, they will have reduced the risk for the producer, who, at present, is assuming too much of the load.

- Possible political impact: the RDP approach inevitably involves political authorities. Building support among them is essential: they can aid in solving problems: technical (selection of producers, technical levels to attain), economic (balances within and between regions, input costs, surpluses and price structures), social (management of rural areas, land tenure), institutional (cooperatives, farmer organizations, credit, marketing), logistical, and political.

RDP: the methods

For farmers to play an active role in selecting their development path, they must be involved in the various phases of creation and extension. Farmers' participation is required, first, in diagnosing the problems, second, in designing technical improvements, and, third, in using and evaluating the innovations. Each phase requires different methods, some of which are available already; others are being developed or have yet to be developed.

These methods seem to me to fall into three categories:

- Evaluations using various criteria and at various phases; the criteria take into account relationships between the ecological and technical environments, between techniques and farming systems, and between techniques and societies. The phases concerned are diagnosis, prescription, explanation, and follow up. The evaluations must recognize and take into consideration the remarkable store of knowledge that the farmers can contribute. The challenge is for researchers to use methods that involve farmers and that draw on this wealth of knowledge, for example, in analyses of soil potential, production of inventories and maps, selections of and decisions about innovations, problem-solving, and resource management. What role do researchers play in the analyses? How can agronomists come to understand farming processes at the various levels (the plot, the farm, the countryside)? How can one get farmers to help evaluate the potential and risks for developing or extending techniques and systems? I believe that the evaluations must be conducted by experienced researchers working directly with the farmers. However, in the traditional linear RDP scheme, those directly involved are development personnel whose level of technical knowledge might quickly be challenged by the farmers themselves.
- Experiments; the methods for testing on research stations or in controlled environments are generally available, and only need to be adapted to the particular constraints and objectives of the experiments. Not so the methods for testing in the actual production environment. Many authors distinguish between researcher-managed and farmer-managed tests, and the statistical and biometric methods for the latter testing have not yet been developed. Some researchers consider farmer-managed tests an extension of experiments started on the station; others see them as the beginning of experiments — the

true framework for dialogue with the farmer. The tests, which are carried out on as many sites as possible, provide information about actual production and consumption at the level of the plot, the farm, the rural community, and the country.

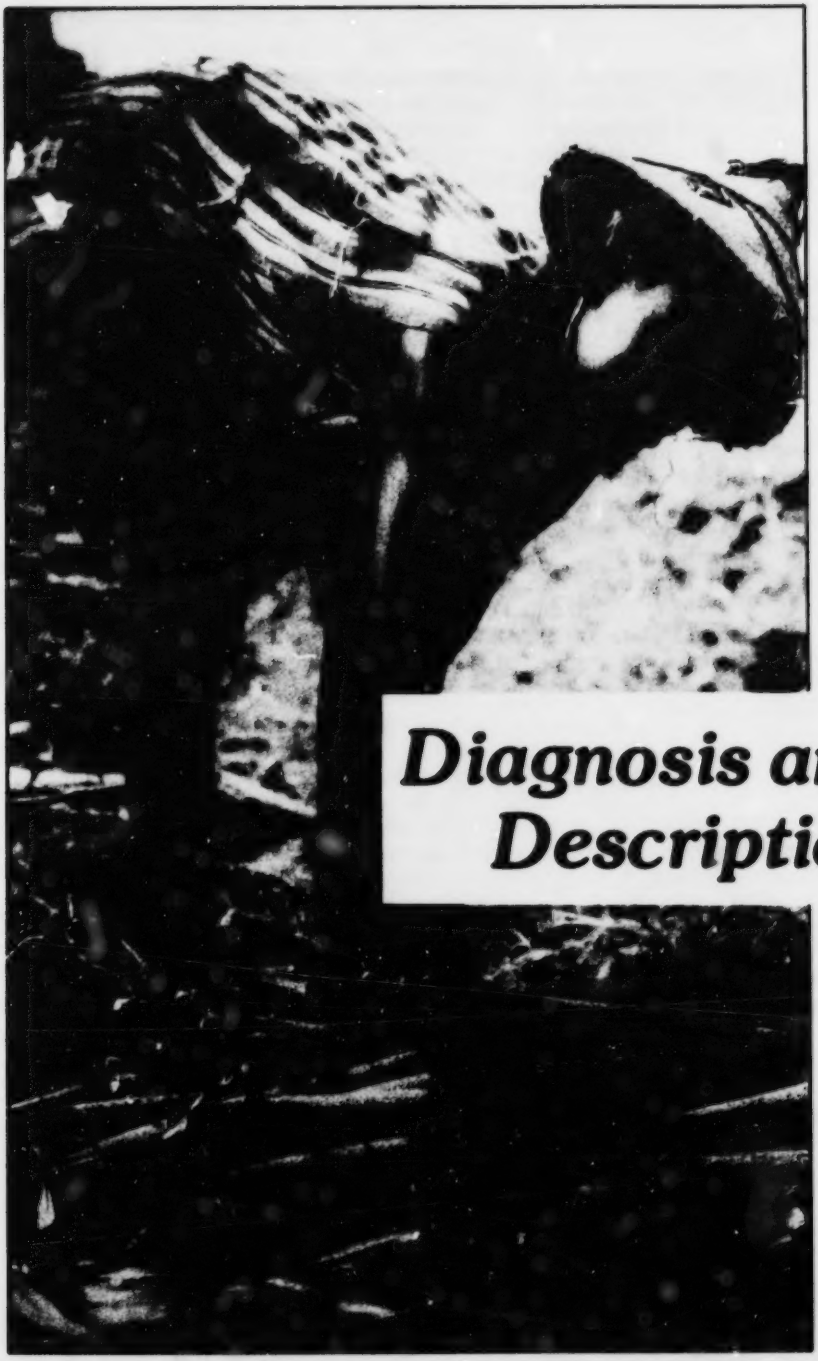
- Adoption, extension, and adaptation; the methods for extension — an experimentation–evaluation process — involve close cooperation between researchers, farmers, and extension personnel in both real and controlled environments to generate innovations adapted to the various types of landscape and production that exist. Some attempts are being made to follow up innovations and establish directions for change and scenarios for the future by taking into account the major social, institutional, and logistical factors of the environment.

But how is the transition in scale to be made from activities in small areas to development at the regional level? Adopting, communicating, and extending techniques in rural areas involve five key elements: choosing sites that represent a large agricultural area (the method found suitable is zoning, although only recently have human, social, and cultural factors been introduced into this zoning); selecting farmer–partners who are also representative and with whom innovations will be negotiated (the methods used currently are to establish structural and functional types of farmers by closely studying communities); communicating and demonstrating possible development plans on the sites in rural communities, with training and professional organization of farmers; assisting farmers to adapt the techniques; and instituting the organizational structures required to complete the undertaking.

Conclusion

The resources and conditions required for successful participatory research and development are a key consideration if more than a small number of farmers are going to become involved. I feel that certain questions must be kept in mind: What is a suitable ratio of farmers to researchers and teams of researchers and extension workers? What is the best way to assist farmers in replicating the models they have developed? What institutional support should be given to the new RDP approach? What means must be developed to communicate the results of the experiments? What role can be played in this communication by the networks of RDP projects? What methods, organizational systems, and procedures will have to be invented so that projects — experiments — take into account the macroeconomy and regional and national policies?

Although the type of participatory research I have described is quite new, it has been the subject of numerous publications. To date, the documents have had a limited impact. I hope that this publication — available in both English and French, in a simple, straightforward style — will be read widely by development personnel, planners, researchers, and extension workers. I also hope that in the future, a workshop about farmers' participation will include farmers.



Diagnosis a
Descriptio

Researchers increasingly consider that rural communities must participate in diagnosing their problems and describing their environments so that technical research can be directed toward more relevant objectives. Only by working with farmers, can researchers assess the strengths and weaknesses in production, the potentials and limitations, the existing know-how, and the misconceptions.

Researchers have been slow to recognize their ignorance of the rural and cultural environments toward which they direct their investigations. The implications of their ignorance have only become clear after years of producing "solutions" that are not appropriate.

Diagnosing the production environment includes describing the physical, ecological, sociological, and technical components as well as the economic, social, and cultural organization; the development; landscape; community; and the institutional environment, with its own constraints, tensions, and contradictions. The process includes a historical analysis, which can often explain present patterns of organization and the evolution of future patterns and problems.

Most researchers are convinced that the information, which is essential to farming-systems research, cannot usually be garnered solely through quick surveys. The time allotted to diagnosis must be sufficient for follow-up, including the systematic mobilization of the data and knowledge of the area studied but not so long as to tire the farmers or to make the conclusions less useful and outdated.

Although diagnosis is a prerequisite for research, it is not static. Diagnosis is continuous, extending to the adoption by farmers of new technologies. It is part of an iterative, creative interaction between farmers and researchers, communities and technologies, and it must be directed toward an analysis of the functioning of the structures rather than of the structures themselves. For example, diagnosis can serve as the basis for evaluating the risks a farmer will take in adopting technical innovations.

The methods available are varied, and the ones chosen will depend on the objectives of the research as well as the resources available for conducting it. Extensive or intensive methods — "one-shot" surveys of large populations vs regular, frequent interviews and follow up of smaller groups — are both appropriate for different objectives, and researchers should recognize that, in fact, the two types complement one another.

The costs of the two types of methods are not that far apart and can be considerably reduced if local observers and even the farmers themselves are called upon for tasks that do not require the special expertise of professionals, particularly those on international salaries. Staff, like methods, should be chosen to reflect the objectives of the research.

Teamwork is necessary between farmers and researchers and between

biotechnical scientists and social scientists; ensuring that these groups work together is difficult but rewarding. It is the focus of this publication; the papers within this section look particularly at the diagnostic and descriptive stage of research.

Helga Vierich examines and provides useful examples of how four sources of confusion in dialogue between farmers and researchers can lead to erroneous and, often, biased information and suggests specific methods to reduce such bias. Next, Christina Gladwin et al. show how researchers can construct taxonomies, plans, and hierarchical decision models based on information obtained from farmers and then use these tools in designing and evaluating techniques.

In his paper, Michel Benoit-Cattin notes that farmers and researchers are only two of the actors in the dialogue and that interactions are conditioned by the political and institutional environment. Michel Braud proposes that the farmers' environments be differentiated as a step toward improving interactions and sets out a low-cost method of classifying farmers. His case study from Upper Volta emphasizes that, if development institutions focus on specific farm types, they can undertake adaptive research and farm-management counseling, with the farmer as an active, not passive, partner.

An overview of the early stages of a farming-systems research program in Zimbabwe is presented by Malcolm Blackie. His paper demonstrates how farmers' contributions were used to define a research agenda and how survey methods had to be adapted to conform to farmers' conceptions.

In their paper, Mahlon Lang and Ronald Cantrell spell out their experiences in Upper Volta with two alternative methods of survey design: intensive cost-route surveys that can support quantitative modeling of production systems and "one-shot" extensive approaches. They characterize the former as being slow, demanding of scarce technical resources, and as involving farmers as passive respondents; they found that the latter draw more broadly and actively on farmers' and interviewers' knowledge, produce results more rapidly, and economize on human and financial resources. The two authors conclude that the extensive methods are cost-effective and, thus, appropriate for national agricultural research programs with limited resources.

In the final paper in this section, John McIntire, assuming equal benefits from the two methods, analyzes the costs through detailed examinations of the present values of actual research program budgets. His findings underline the disproportionately large share of costs represented by expatriate professionals in many farming-systems research programs.

The discussants — Diallo, Binswanger, Eponou, Billaz, Pocthier, Hildebrand, Singh, and DeWalt — point out strengths and weaknesses in the papers and elaborate on their experiences with survey methods.

Accommodation or participation? Communication problems

Helga Vierich, *International Crops Research Institute for the Semi-Arid Tropics, Ouagadougou, Upper Volta*

If communication were simply a matter of talking, this paper would not need to be written. However, everyone is aware that problems of communication plague people who come from the same culture and speak a common language — even people who have lived together intimately for years. When scientists with Western training attempt to exchange information and ideas with farmers in the Third World, they confront a profound communication gap. This gap is all the wider for being deceptively easy to bridge on occasion. It is a gap not of language per se but of culture (Lee 1950; Hall and Foote Whyte 1960; Bohannon 1966; Lee 1969a). The gap also exists between the various scientific specialties, for the concepts, methods, and language that lend to each discipline its special strength also frequently block communication between disciplines. The communication problems between disciplines may be even more serious than those between farmers and researchers because of rivalry, especially in these days of limited funding. When professionals fail to communicate effectively, they do not respect each other's theory and methods, and I think there is scant hope that they will communicate constructively with farmers.

Sources of confusion in communications result from people's failure to distinguish between stereotyped and spontaneous behaviour; group and individual behaviour; ideal and real behaviour; and folk vs scientific descriptions and analyses. I have focused on how these affect communication between farmers and researchers and between researchers from different disciplines.

Farming-systems research differs from previous approaches, such as dependency theory, diffusion, and farm management, generated by economists to deal with Third-World subsistence production (Eicher and Baker 1982) in that it centres on two notions:

- That the farm comprises numerous subsystems, economic and social, that are integrated into a village-level system. As the system is too large and too complex to be studied by one discipline alone, farming-systems research ideally involves multidisciplinary teams.
- That farmers and researchers can work together in testing and developing improvements in technology. Ideally, this partnership operates in a context in which the researchers understand fully the particular farming systems.

Communication between scientists of different disciplines and communication between farmers and researchers are both critical to the success

of the approach. Farming-systems projects usually move through several stages: baseline research to identify major constraints to productivity, development of technical proposals to relieve the constraints; exploration and testing of improved technology. If the technology proves promising under indigenous conditions, it is referred to national extension services with recommendations about its appropriate use. Throughout, communication between researchers from different disciplines is as essential as communication with farmers.

Each specialist views the system from a different perspective and can contribute to the whole picture. But all the specialists must work together. In the beginning, the social scientists collect and analyze data; even within the social sciences, however, the different specialties have divergent perspectives. For instance, an anthropologist and economist working together are likely to derive a more accurate, comprehensive picture of the farming system than would either one working alone. The data collected by the social scientists allow one to identify the problems that can be addressed by plant breeders, agronomists, veterinarians, or other agricultural specialists. In other words, the types of data to be collected and the stages of the research determine when a particular specialist should be involved.

At each stage, the researchers must communicate with farmers. Baseline data cannot be collected without their cooperation, and their input is critical in the identification and elimination of constraints. The understanding of farmers is essential to successful development of technology.

Stereotyped vs spontaneous and group vs individual

The differences between stereotyped and spontaneous behaviour are closely related to the differences between group and individual responses and behaviours. Stereotyped responses are most common when people are in groups and can be most pronounced when two or more ethnic groups are interacting. Although people commonly think of stereotypes as images that one group has of another, such as the Hollywood-created stereotype of North American Indians, research indicates that people often act out the behaviour expected of them.

In all cultures, some behaviours are immediately recognized as role playing. In the West, each profession tends to be associated with a particular stereotype, and even the word "professional" implies a particular role. The ability of an individual to slip into the appropriate behaviour is one of the most admired qualities in Western culture, and a person can be ruined by a single "unprofessional" performance.

Farmers, too, when dealing with researchers, speak and act out publicly defined roles. Within their culture and community, they also have to make and maintain reputations. The answers a farmer gives to an outsider's questions in public are likely to differ from those provided in private.

The distortions in communication caused by role behaviour in the context of a single culture and ethnic group pale when compared with those in the context of multiple ethnic groups or social classes. Some of the strongest behavioural stereotypes are associated with ethnic differences, particularly when each ethnic group plays a different role in the economic life of a community.

During my fieldwork among farmers and hu ers in the Kalahari of southern Africa, I worked among two different eth groups: the Bushmen and the Bantu. The former are primarily hunter–gatherers and stereotyped by the Bantu as poor, lazy, crafty, and generally inferior. The Bushmen, meanwhile, consider the Bantu farmers to be greedy, cruel, and wealthy. Although the economies of the two groups differ, they overlap: the economy of poor Bantu is like that of Bushmen: they gather wild plants, hunt, and work for the Bantu. Some poor Bantu even assume Bushmen identity, marry into Bushmen communities, and generally are accepted as Bushmen. By the same token, Bushmen can "become" Bantu, although this is rare because it involves amassing livestock and investing considerable capital to become a successful farmer.

When I began to gather data on wage and in-kind labour in agriculture, I was told that hired labourers were Bushmen and that Bantu never worked for other Bantu. Later, I began to notice that a number of Bantu families were being "helped out" by other Bantu who were called visitors. In fact, Bushmen employees had essentially the same arrangements as Bantu "visitors" — both a daily payment (usually food and lodgings) and a final payment (part of the harvested grain). Hired crop work was so thoroughly identified with the Bushmen that Bantu who did this kind of work consistently denied it, claiming rather to be visitors in the household of their employers. Only after some months did these "visitors" admit to me privately that they were "nothing but Bushmen" because they were doing the same kind of work (*majako*). Although, at the outset, "visitors" claimed a distant geneological tie with their hosts, for many, the "visit" was the first time they had met one another.

A rapid survey by someone unfamiliar with these interethnic relations would have given a totally false impression. In fact, a rapid survey might not even have revealed the presence of two ethnic groups: the Bushmen almost always try to pass themselves off to visiting Botswana government officials as Bantu, as they see this as the more desirable identity to have when dealing with the Bantu-dominated bureaucracy. When white visitors arrive, even the Bantu don leather clothing and claim to be Bushmen because they know Europeans like to take pictures of Bushmen and buy trinkets from them.

That there are some ethnic groups stigmatized so completely that they conceal their true identity in the presence of outsiders would be relatively unimportant in farming-systems research if access to resources and status were not divided along ethnic lines. In Africa, at least in rural areas, land has traditionally been controlled by the dominant group in the territory. Thus, a minority ethnic group might find that they can survive and participate in society only if they assume the ethnic identity of the dominant group. In Upper Volta, for example, in an ICRISAT study village of Mossi, some members are from another tribe. The difference in origin is at the root of several long-standing disputes, including who has the right to assume public offices such as chief, master-of-the-land, chief experimenter, organizer of ceremonies, and master-of-granaries.

In the ICRISAT Sahel villages, there are complex relationships between four different ethnic groups: the Mossi, Fulse, Fulani, and Rimaibe. Mossi farmers have migrated to the Sahel from the overcrowded Mossi plateau and have gained access to land through Fulse chiefs (or land masters). They

could have asked the Fulani chiefs for land but may have avoided doing so because the Fulani, even today, consider all the terrain not occupied by the Fulse to be alienable if a Fulani has need of it. Curiously, as the Mossi ethnic group is dominant in Upper Volta, and prominent in the government and civil service, the Fulse have begun to say that they are Mossi. The two groups at times intermarry and may be merging. Meanwhile, the Rimaibe, who were originally servile communities of farmers under the domination of the Fulani, do what they can to claim Fulani identity, especially in seeking employment in Ghana and Ivory Coast during the dry season. Since the 1930s, they have also begun to acquire cattle — an activity previously prohibited by the Fulani — and a number have taken up the lifestyle typical of affluent rural Fulani, living in conical huts near the encampments of their former masters.

When I began my fieldwork in this area, it took me a week before I realized that I was interviewing Rimaibe and not Fulani. Having read literature on the Fulani's origins, I was becoming discouraged by the discrepancies between what I had read and my own field notes. The latter indicated that the population was at least partly composed of former Mossi who had either fled the French or had been brought to the area as slaves by the Canton chiefs in Djibo. Their responses to questions regarding farming and livestock tended to be in terms of Fulani norms, which are rarely attained, except by the more affluent Rimaibe.

These examples indicate that:

- The results of rapid surveys must be regarded with caution, especially as a basis for identifying major constraints within a farming system, planning appropriate technologies, and distributing resources;
- Involving farmers in group discussions is not the most effective way to elicit their views about new technology, their problems, or even their agricultural activities; and
- Selecting sample groups of farmers for individual follow-up is best left until the major divisions within the community have been defined on ethnic or economic grounds.

The ideal and the real

Rules and action do not always coincide. Every community has its rules — culturally prescribed behaviours — and these define tradition. The rules and traditions are information economies (Beals 1967). In African societies, they are controlled by tribal elders; in the West, by parents; schools; professions; and radio, television, as well as other media. The economic and social lives of all people are, to some extent, conducted according to the rules.

Researchers who want to work with farmers usually begin by learning the rules governing traditional agriculture, asking, for example: When should one prepare a field, plant, weed, harvest? How should the hoe be used? How deep should the seed be planted? How many seeds should be used in the same pocket? How far apart should the seeds be planted? How often must the plants be thinned? When should the fields be cleared of crop residues? When should new fields be cleared? When should manure be applied? The list goes on.

When they have gathered the rules, do the researchers know what people are doing? The answer is no. They have learned what farmers think they should be doing. Like any set of conventions, agricultural traditions are variously and individually interpreted and applied.

A study of the difference between rules (ideals) and behaviour was done by Rada Dyson-Hudson (1972) among the Karamojong of Uganda, pastoral peoples who raise livestock. If asked, they would say that men and boys herd cattle; women and girls work in agriculture.

Dyson-Hudson worked with the Karamojong for 3 years and found that this statement was not accurate. Although the women cleared the fields, men accounted for 35% of the labour in planting sorghum and fully half of the labour in planting millet. In weeding also, men and older boys accounted for about one-third of the labour, especially on millet fields in the bush. Men accounted for more than half the labour during the harvest.

Dyson-Hudson observed (1972:46):

> quantitative studies of actual behaviour patterns . . . revealed . . . important differences between self-image and behavioral reality. Only by focusing on the actual behavior patterns were we able to appreciate the complexity of . . . sexual division of agricultural labour activities. . . .

She also noted that male participation in farming was highest in households with few cattle. Thus, I believe that the Karamojong expressed not what most people do (derived from an average) but rather what most people would do if they were rich enough. The norm as presented to outsiders is skewed toward the real behaviour of wealthy and successful Karamojong: the good life, Karamojong style.

This is not that strange. If Americans are asked to tell an outsider what is the essential way of life in their country, they gloss over the vast variations in income and lifestyle and concentrate on an ideal account of what most Americans would consider to be "the good life." Most people in a culture do not actually know the details that go into the whole picture. They tend to describe two things: their own life and the ideal or model way of life in their culture. Asked by an outsider, most hesitate to discuss their own life because it is too personal or embarrassing. Besides, they are being asked to represent their culture. Thus, one could ask everyone within a culture and arrive at nothing but a version of "the good life." Getting at reality requires careful observation and detailed inquiry into the economic affairs of individuals.

Ideals such as "the good life" are part of the cultural traditions of all peoples. The traditions are distilled accounts — the essential behaviours and knowledge guiding each member of a particular society. They change as people change the way things are done. But changes in tradition lag behind changes in practice.

The flexibility to accommodate changes in what people do is essential to every people. Each culture has its experimenters, its radicals, and deviations from the norm are tolerated, even encouraged, to some degree. If societies were to stifle all experimentation and innovation, they would die out. So it is with agricultural traditions. Researchers should expect to find variations in practices and should keep in mind that they are dealing with an evolving and dynamic system. How often and in what ways actual practice deviates from

traditional practice are good indicators of stress. When farmers encounter difficulties with which their traditions cannot cope, they begin to experiment. The scientist can learn much about the constraints and stress within a farming system by following the lead offered in farmers' own experimentation. It is in these areas of difficulty that farmers will be most open to any new ideas and outsiders' suggestions and will participate most eagerly in researcher-introduced projects.

Traditions do not hang together in shreds and pieces; they are woven together by a set of explanations. In science, the explanations are called theories (Kuhn 1971); in nonscientific settings, folklore or folk science.

These frameworks of explanation or paradigms are more than explanations, they are *conceptual* tools, organizing the very perception of information. Human beings, more than any other species, are the product of their cultural education. Recent research indicates that children learn their social and physical environment not by a slow, continuous accumulation of knowledge but in a series of stages linked to their growth and mental development. At the end of each stage, according to Piaget (1960:139), there is a "crucial turning point . . . which affects the complex of ideas forming a single system . . . in this there is something comparable to the abrupt complex restructuring described in gestalt theory. . . ."

In adulthood, too, peoples' perceptions are governed by the conceptual universe in which they live. Changes in the conceptual universe do not apparently occur through the accumulation of new information but rather through the kind of sudden "complex restructuring" described by Piaget and exemplified by the behaviour of scientists who must adopt a new theory. Throughout history, there have been reports of the crises that scientists face when they recognize anomalies in their data that cannot be explained by their current paradigm. Kuhn (1971:122–123) observed that these:

> crises . . . are terminated, not by deliberation and interpretation but by a relatively sudden and unstructured event like the gestalt switch. Scientists then often speak of "scales falling from the eyes" or of the "lightening flash" that "inundates" a previously obscure puzzle, enabling its components to be seen in a new way that for the first time permits the solution. On other occasions the relevant illumination comes in sleep. No ordinary sense of "interpretation" fits these flashes of intuition through which new paradigms are born.

If, in fact, paradigm-learning involves the restructuring of perception, it is probably not under voluntary control. Neither are gestalt switches. For example, in experiments where people were fitted with inverted goggles, they went through a crisis initially because they saw the world upside down but felt it right side up. Then, abruptly, their brain "adjusted the picture" and the whole visual field flipped over. Learning a new paradigm is like learning a new language. To be really comfortable within a language, people must internalize it and stop translating.

Every culture has a unified set of explanations (the paradigms) that provide coherence to people's perceptions and communications. Language is one obvious subset, but language alone does not constitute a person's paradigm. People who share the same paradigms but speak different languages can readily read translations of each other's literature, whereas

people who speak the same language and live in the same culture but have different paradigms often cannot communicate at all.

Major scientific advances probably seldom cause paradigm shifts among the general public. Even with mass education, it takes many generations for fundamental ideas such as the germ theory of disease, evolution, the theory of relativity, to penetrate the whole society.

Systems of explanations in agriculture and animal husbandry are no exception. Nor is the organization of economic life: social scientists often talk of the "idea of money" lagging behind the introduction of money and its general use, and children must be trained in the properties of money, first through the use of the piggy bank then their own bank account.

The paradigm or framework should not be confused with the information upon which it is based. Modern agricultural practices may be adopted without their underlying paradigm, even if the scientist or extension officer thought he or she "persuaded" farmers to try the new practice on the basis of its scientific explanation. For example, sheep farmers in the Andes have to some extent adopted the practice of docking the tails of their sheep. This practice was explained in terms of improved hygiene and better conception rate: the tail of the sheep did not accumulate feces and bacteria and did not get in the way when the ram mounted the ewe. However, the Andean shepherds who adopted the practice apparently did so within the framework of their own system of explanations. The folk explanation for docking is in terms of calming unruly sheep. The people believe that if a sheep is left with its tail intact, the tail will somehow compete for nutrients with the rest of the anatomy, and the sheep will grow thin and weak. The result of this particular system of explanation is that docking is sometimes done after a sheep becomes unruly, or sickens, rather than just after birth as the veterinary services propose. Docking seems to have been confused with castration. The Andean peasants do not have a germ theory of disease with which they can connect docking to less dirt to less disease. So they apply a theory familiar to them from another context in which a similar operation is involved (C. McCorkle, personal communication).

In Upper Volta, ICRISAT staff discovered recently that farmers in one of the study villages were using potent herbicides along with recommended insecticides in their grain storage. Why? They had been using insecticides in the stores for at least 10 years and had introduced herbicides when the cotton company's extension agents convinced them to use both chemicals in the cultivation of cotton. The powders, like powerful potions in folk medicine, were thought by the villagers to have magical qualities that protected plants and grain from harm by evil influences such as insects, spoilage. Like the native medicines, they were accepted as cure-alls, or, in this case, protect-alls. So the herbicide left over from the cotton spraying was being mixed with insecticide and used in the grain stores.

Folk vs scientific explanations

Many of the pieces of information that farmers have are similar if not identical to those upon which scientific explanations are based, and farmers are able to share and exchange these pieces with an agronomist, plant breeder, or veterinarian easily and with a minimum of confusion. Confusion

Scaring the birds from the sorghum fields: the simplicity with which the gap in culture can be bridged at times can lull researchers into thinking they understand farmers.

arises when the scientists assume that farmers understand why the practices work.

The power of scientific explanations is that they are usually based on methods of investigation that systematically link facts. Modern science was developed to cope with the ever-growing body of information made available by technological advances in data gathering (telescope, microscope, tape recorder, camera, stethoscope, x-ray films, etc.).

For example, when someone is ill, relatives may say the cause is witchcraft. A doctor trained in Western medical science will diagnose malaria. The explanation offered by members of the sick persons' own cultural group is based on "folk science" or folk systems of explanation, whereas the doctor's explanation is offered on the basis of the information and explanations derived from experimental medicine.

Similarly, a visitor to the tropics who comes down with chills and fever may announce: "I think I have a touch of malaria" only to find out from a doctor that the "touch of malaria" is in fact the flu. The visitor has arrived at a "folk" explanation.

There are two pitfalls created by scientific explanations:

- They are sometimes evoked without adequate investigation; and
- They sometimes lead scientists to ignore the value of traditional practices for which folk explanations are inadequate.

A number of studies have shown that, despite the inadequacy of folk explanations, the practices may be quite sound. Finding the scientific rationale for traditional practices has recently become popular (Codere 1950; Leacock 1954; Harris 1959a, b; Rappaport 1966; Lee 1968, 1969b, 1973; Gross and Underwood 1969). Perhaps the best known example is

Marvin Harris' treatment of the "myth of the sacred cow" in India. He concludes that the taboo against the slaughter of cows makes sense in view of their production of oxen that are critical to Indian agriculture, their production of milk and dung, and their ability to convert marginal grazing resources into products useful to the human population (Harris 1971:571).

> When hunger stalks the Indian countryside the slaughter taboo helps peasants resist the temptation to eat their cattle. If this temptation were to win out over religious scruples, it would be impossible for them to plant new crops when the rains began.

On the Mossi plateau in Upper Volta, people can be found gathering the old fallen sorghum and millet stalks and burning them during the months preceding the rains. They call this the "cleaning of the fields." In some areas, the practice is a ritual, but, in the ICRISAT study villages, people offer no special reason for the custom. Rather than condemn the practice as useless or as a waste of potential mulch, one could search for a scientific explanation of the benefits. For instance, by burning their stubble, people may be inadvertently killing insect larvae and eggs or fungal spores that are dormant in the dead plant material throughout the dry season. These would otherwise infect the new crop.

Implications for dialogue

When researchers ask farmers questions and get meaningful answers, they forget that the farmers do not share the same paradigm. The farmers have their own way of organizing reality (Kaplan and Manners 1972:22).

Furthermore, the farmers may have learned, from previous exposure to other researchers, extension workers, and other farmers, the fundamentals of the model they assume the researcher expects. Thus, they filter their answers through the fabric of information they have, even though the result is an imperfect translation of the way they understand and do things. Meanwhile, researchers may well attempt to do the same thing: they filter their questions through what they think is the folk or indigenous system of beliefs.

When preparing and testing survey instruments, researchers should review all available literature about the people to be studied so that their sampling procedures and questionnaires take into account ethnic groups, social classes, political organization, indigenous economic practices, and systems of access to basic resources. In this way, they can minimize sources of confusion arising from stereotypes.

If they interview people, they should verify the statements by direct observation and by complementary data collection (use of regional statistics, measurement of crucial variables such as changes in body weights, units of measure in transactions, use of aerial photographs, soil surveys). This approach ensures that field data reflect real rather than ideal behaviour.

They should assemble translations of the folk-science explanations specific to each area of team inquiry. In other words, the ethnology of the farming system should be researched, including indigenous practices of plant breeding and selection; experimentation with new varieties and technologies; soil classifications; economic exchanges; long- and short-term reciprocity; etc. The roles of large-scale economic activities such as ceremonies, work

gangs, systems of tribute, institutions of clientage, land tenure, institutions regulating disposal of grain and other goods, and investment and long-term planning should also be translated and their effects on farmers' management practices assessed. Thus, confusion arising from poor translation of folk into scientific explanations can be avoided.

Models of the overall farming system should be based on analysis of data that are most likely to conform to what farmers are actually doing and on testing of scientific hypotheses concerning this behaviour. This step ensures that beneficial practices are not disregarded simply because the folk explanations for them are inadequate.

The data collected during baseline surveys can be used to test many of the hypotheses and should provide a clear understanding of the most pressing constraints on the productivity within the farming system. In most cases, these will relate to the problems suggested by the farmers, although the scientists' analysis may produce explanations that the farmers were unable to provide. At other times, the farmers may stress problems that are not borne out by analysis.

When the technical problems emerge from the analysis, the researchers can focus on those that they might help to solve and that are recognized by the farmers.

The farmers and the appropriate technical scientists can then begin to work on improving existing technology. During this process, the farming-systems team will expand, and new members should be provided with background on the farmers' world view. If at all feasible, the testing should fit the farmers' own system of farming, breeding, husbandry, storage, cooking, and experimentation. Thus, for example, tests to be managed by the farmers could be designed to conform with the way the farmers have usually done their own experiments. Finally, the researchers should get together regularly, perhaps weekly or monthly, and make formal presentations on their methods and progress.

Using ethnoscientific tools to understand farmers' plans, goals, decisions

Christina H. Gladwin, Robert Zabawa, and David Zimet, *Food and Resource Economics, University of Florida, Gainesville, USA*

Farming-systems research and extension programs are now generally viewed as having some hope of increasing food production on small rainfed farms in the Third World (Gilbert et al. 1980; Shaner et al. 1981). Approaches to farming-systems programs are varied, with debates raging about "downstream" vs "upstream" approaches, and FSIP vs FSR/E (the farming systems' approach to infrastructural support and policy vs its approach to technology generation, evaluation, and delivery) (Norman and Gilbert 1981; Norman 1982).

In general, however, all farming-systems programs share (Hildebrand and Waugh 1983:4):

- A concern with small-scale family farmers who generally reap a disproportionately small share of the benefits of organized research, extension, and other developmental activities;
- A recognition that a thorough understanding of the farmers' situation is critical to increasing their productivity and to forming a basis for improving their welfare; and
- The use of scientists and technicians from more than one discipline as a means of understanding the farm as an entire system rather than the isolation of components within the system.

The focus of a farming-systems program is the farmer, rather than the crop, the technology, or the environment (CIMMYT Economics Program 1980). The farming-systems approach thus starts with the farmers' constraints and develops, through experiments on their fields, recommendations to improve their family's standard of living. Most farming-systems programs accomplish this aim via a multidisciplinary team that, first, diagnoses farmers' problems, goals, and constraints; second, identifies new technologies or strategies to deal with or alleviate those constraints; third, tests the promising technologies or strategies via experimentation and on-farm tests; and, fourth, diffuses or extends the new technologies or strategies to the local farmers (Gilbert et al. 1980).

As farm trials and farmers' tests are on farmers' fields and the farmer is consulted during both the diagnostic and the evaluation stages, the farmer is clearly at the centre of the program and farming-systems projects all espouse the goal of involving farmers more explicitly at each stage (of diagnosis, technology development, and technology assessment). However, as noted by the sponsors of this conference, " . . . the goal of direct and creative farmer participation has been elusive. . . ."

How to increase and improve direct farmer participation — and at which stage(s) — has been widely debated. At one extreme are those who call for continual but informal contact with participating farmers, disavowing all formal social-science surveys as "superfluous," not directly useful to the technical team designing trials and offensive to farmers who have been researched to death (P. Hildebrand, personal communication). At the other end of the spectrum are those who subject farmers to nine different kinds of questionnaires on a weekly, monthly, and yearly basis for 4–5 years (Ryan 1977).

Based on the Economics Program at CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo), we propose a compromise solution — a mixture of an initial, informal phase and a formal follow-up (Winkelman and Moscardi 1981). Our solution differs from CIMMYT's, however, in aim and purpose. Rather than focusing on factual data collected to test scientific theories about farmers, the "ethnoscientific" approach to increasing farmer involvement concentrates on cultural symbols used by farmers. The aim is "to grasp the native's point of view, . . . relation to life, . . . vision of [the] world" (Malinowski 1922:25). To see the insider's world through the insider's eyes is the goal of ethnography, which differs from other social sciences in its emphasis on indigenous or folk knowledge rather than on scientific knowledge. Because "the subject matter in ethnoscience is not environmental phenomena as such, but people's knowledge and interpretation of these phenomena" (Glick 1964:273), an ethnoscientific approach to involving farmers in farming-systems research is quite different from previous approaches. It differs most notably in use of trained personnel and choice of research tools. To acquire an understanding of folk or indigenous knowledge systems in a natural way (Brokensha et al. 1980), ethnoscientists participate and live in the culture they are observing, often for extended periods (Spradley 1979). To test their understanding, they model farmers' knowledge of the meaning of important cultural symbols in their farming systems. This indigenous or folk knowledge can be summarized and represented in taxonomies, plans or scripts, goals, and decision models. To describe and illustrate the usefulness of these tools, we present models of farmers' classification systems, decision processes, goals, and plans, and show how we use them to understand and evaluate traditional farming systems of family farmers in north Florida. Our models of farmers' folk knowledge are " 'micro' in scope and deal mostly with conditions inside the farm gate" (Hildebrand and Waugh 1983:4). As such, ethnoscientific research falls within an FSR/E rather than FSIP program.

Taxonomies

The pillar of ethnoscientific tools is taxonomy, based on the relationship "x is a kind of y" (e.g., trees and flowers are kinds of plants; oaks and elms are kinds of trees; white and red are kinds of oaks; etc.). More formal definitions are found in Frake (1971), Kay (1971:868–869), and Werner and Schoepfle (1979:49–50). Taxonomic analysis searches for the internal structure of domains, which are sets of cultural symbols that carry meaning for and to the members of the culture.

For an example of a taxonomy, let us look at the case of Gadsden County, north Florida. For the better part of its agricultural history, Gadsden County's farming has been based on "shade," or cigar wrapper, tobacco. At its height, shade tobacco was planted on more than 2.4×10^3 ha, produced more than 3.6×10^3 t annually, and accounted for 65% of the value of all agricultural products in 1969, and 45% of the value of all agricultural products in 1974, just 3 years before it dropped out of production completely (US Agricultural Census 1974, 1978). Shade, as a type of tobacco, was first developed during the latter part of the 19th century. During the 1890s, the area's tobacco industry was being revived through the production of "sun," or cigar filler, tobacco (Womack 1976:99–101). Growers soon discovered, however, that the light-coloured, silky leaves found near the shaded base of the plant and on plants shaded naturally by trees brought the highest prices at market because these leaves made the best cigar wrappers. Until the mid-1970s, shade was a labour-using, land-saving, ideal crop for Gadsden's relatively small fields with rich soils. Because production inputs for shade were supplied partially by tobacco companies who established a formal "forward contract" with the farmer, shade was not a risky crop to produce, even though input costs increased from $3125/ha in 1955 through $7500/ha in 1968 to more than $17 500/ha in 1977. At the same time, the farmer's profit margin remained in the range of $2500–5000/ha, with increasing costs of production (mostly labour) keeping the profit margin down.

Shade tobacco was also part of a more general farming strategy. Although shade tobacco received the most attention, other commodities (e.g., cattle and corn) were managed around the production of shade tobacco. The cattle were maintained for their manure that was added to the soil to maintain soil structure and supplement the chemical fertilizers. Corn was produced mainly for cattle feed. Interestingly enough, farmers frequently stated that the value of cattle and corn was associated only with their benefit to shade tobacco; in and of themselves, they were only breakeven ventures.

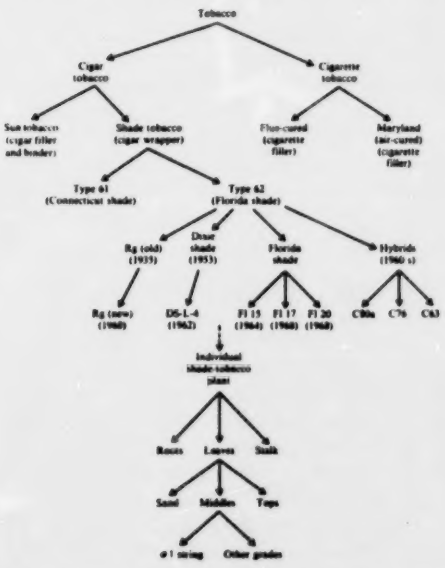


Fig. 1. Ethnoscientific taxonomy of Gadsden farmers' understanding of tobacco.

During the decade 1967–77, however, shade tobacco as a farming system and the basis of a unique farming culture disappeared because of increasing costs of production aggravated by increasing labour costs; competition from Central America where a shade tobacco industry based on cheaper labour was developed with the help of the US government and some Gadsden

farmers; the development of synthetic or manufactured "homogenized" wrappers for cigars and the use of a plastic tip that eliminated the need for a full leaf to hold the cigar together; and the decline in the demand for cigars (Plath 1970). The traditional farming script thus interrupted, shade producers had to decide whether to continue the traditional farming system and find a crop similar to shade tobacco, to change their farming system drastically and increase their row-crop and livestock operations, or to cut back substantially and even drop out of farming completely. To understand how they made this difficult decision, one must understand how they thought about shade tobacco and what meaning shade had in the culture of Gadsden County, which had, after all, developed for 80 years around the crop.

To find a substitute money crop for ex-producers of shade, a member of a farming-systems team could consult the USDA (United States Department of Agriculture) classification of the different kinds of foreign and domestic tobacco (Gardner 1951:18). But, because farmers' decisions and survival plans depend on and are influenced by *their own knowledge* or perception of tobacco, rather than USDA's knowledge of tobacco, a more useful approach is to understand shade tobacco as the farmers do. Thus, an ethnoscientist would elicit the classification structure of tobacco internal to the Gadsden farmer. Briefly, this taxonomy (Fig. 1) says that, first, Gadsden farmers classify tobacco by use, into cigar tobacco (sun and shade tobacco) and cigarette tobacco (flue-cured and air-cured, Maryland) (Zabawa and Gladwin 1983). At the next level, shade tobacco, used for cigar wrappers, is distinguished from sun tobacco, used for cigar fillers. Produced in Gadsden in the 1930s, sun tobacco production declined as shade tobacco became more prominent.

Since the 1930s, the national government has controlled production by granting farmers the right to grow flue-cured tobacco in small areas or allotments, with a ceiling at 175 acres (ca 75 ha) total in Gadsden. Maryland tobacco was briefly introduced in the county in the 1960s, but production declined shortly thereafter when pressure from Maryland legislators forced Gadsden farmers to include Maryland tobacco as part of their flue-cured allotment. This action effectively squelched any attempt by Gadsden farmers to adopt Maryland tobacco because they had been growing it to increase their production over and above their flue-cured allotment.

The lower taxonomic levels further specify different varieties of shade tobacco (Type 61, Type 62 or Florida shade), and different varieties of Florida shade (Rg, Dixie shade, Florida shade, and the hybrids). Partonomies or part–whole relationships then distinguish meaningful parts of the individual plant for the farmer: the roots, stalk, and leaves are important parts of the tobacco plant. Because the shaded leaves contain the plant's economic value, "sand" leaves (the bottom two or three marketable leaves) are distinguished from the "middles" (the next 4–19 leaves, among which the most desired leaves are usually found), and the "tops" (the upper 24 marketable leaves on the plant). The taxonomic structure can be carried one stage further in the marketability of specific kinds of leaves. For example, the most profitable of the "middles" were called *number one strings* and sold with no further grading, whereas the rest of the leaves went through a grading procedure developed by the tobacco companies.

The taxonomy of shade tobacco thus represents the knowledge structure Gadsden farmers have developed while growing shade. A farming-systems team can consult the taxonomy for possible substitute money crops. Indeed, the second level taxa — flue-cured tobacco and Maryland — would have been logical alternatives to shade if government controls had not prevented increases in the production of these crops.

Gadsden's farmers thus had to switch to money crops outside the domain of tobacco. How did they make that decision? In most cases, they searched for and found alternative crops (such as tomatoes, nursery crops, or pole beans with squash) that caused only a small disruption to the original, formerly successful crop plan or farming system. A knowledge of how they grow shade — their plan or script — would be essential in identifying a similar crop.

Plans and scripts

Instead of deciding how to do something every year, farmers develop a plan or inherit a plan already developed by their parents or grandparents. The plan, "how to do x," is a sequence of mental instructions or rules that tell the actors *who* does *what*, *when*, and for *how long* (Werner and Schoepfle 1979). The rules could be considered by the outsider to be a set of decision rules. To the insider or decision-maker, however, they are not *decision* rules, because he or she is not *aware* of having had to make a decision. The decision is made so frequently, so routinely, that the decision rules become part of a preattentive plan or "script," like the script in a play that tells the actor what to say and do (Schank and Abelson 1977). By means of these scripts, the farmers do not have to make a million decisions; they *know* how

Table 1. Gadsden County farmers' plan for shade tobacco (Kincaid 1960).[a]

Timing	Task
January	Plant seed beds
January – February	Prepare soil; fumigate; fertilize
March	Harrow soil into rows about 3 weeks before transplanting seedlings; install shade cloth shortly before planting
Late March – early April	Transplant and irrigate seedlings in the shade; replace missing or weak plants within a week; dust plants with insecticides every 7 days; plow the rows twice a week (discontinue near harvest time to prevent damage to the leaves)
April	String plants (starting when plants reach 0.3 m), spirally from the stalk near the ground, to the overhead wire above the row; continue to string, spirally between the leaves, once or twice a week depending on rate of growth
May	Water when needed using overhead irrigation system
June	"Top" plants to prevent budding if desired
July	Harvest 7 – 8 weeks after transplanting; harvesting consists of picking the desired leaves off each plant, i.e., "priming" (there can be 2 – 5 leaves per priming and 6 – 10 primings per plant); placing the leaves in the order picked and hauling them to the tobacco barn; stringing the tobacco in the barn; curing the tobacco in the barn (3 – 5 weeks); and delivering the tobacco to the packing house
August	Clean up and prepare for a fall crop (e.g., pole beans) if desired

[a] Labour force was primarily local blacks.

Table 2. Gadsden County farmers' plan for staked tomatoes.[a]

Timing	Task
December – January	Prepare the soil, add lime; order plants
February	Lay plastic mulch on the rows; fumigate; fertilize
March	When plants arrive, transplant them into the fields about 15 March (plants are watered through trickle irrigation that is under the plastic; soil treatments are applied under the plastic as well; plant treatments are applied through overhead irrigation if available, or by portable sprayers); spray plant treatments on every 5 – 7 days to prevent insects and disease
April	Stake plants about 2 weeks after planting; start horizontal stringing 2 weeks after staking and continue every 2 weeks until there are four horizontal rows of string per row of tomatoes
May	Complete stringing; irrigate as needed
June	Start hand-harvesting the "green" tomatoes; delivering them to the packing house for shipment; harvesting involves picking through one field, moving to the next field, and allowing the tomatoes to mature before beginning to pick again; start picking "pink" tomatoes when they represent about 10% of the tomato population — about 2 – 3 days after harvesting begins (the "pinks" are harvested by independent migrants who pay the farmer a flat rate per box of picked tomatoes and then sell the tomatoes at farmers' markets)
July	Open fields for "you-pick" operation at the end of harvest and before cleanup operations ("you-pick" is saved for last to prevent damage to the plants and the spread of disease from other fields)
Late July – August	Clean up: burn the plastic string off the old plants with a 2-row propane burner; pull up the stakes and store them; mow the old plants down and harrow them into the ground; and prepare for a fall crop (e.g., pole beans) if desired

[a] Labour for land preparation, transplanting, staking, and stringing is supplied mainly by local black residents; harvesting is done mainly by migrant workers of Spanish descent from south Florida, Texas, and Mexico.

and when to plant shade tobacco, probably because they were taught by their parents.

Eventually, this knowledge will be passed to a new generation as a "traditional" way of doing things. When the new generation of farmers is asked *why* they do things the way they do, they may reply, "It is the custom." Some of them may even forget the original decision criteria; they only know that, for some reason, the traditional way is "the best" way to do x, given the original constraints or criteria used or faced by their grandparents and parents. Examples of such inherited scripts or "adaptive" strategies abound in the literature for economic and ecological anthropology (Bennett 1969; Johnson 1971; Cancian 1972; Brush 1976; Mayer 1979; Moran 1979; Barlett 1980; Chibnik 1981).

The Gadsden farmers' plan or script for shade tobacco (Table 1) (Kincaid 1960) was quite similar to that for staked tomatoes (Table 2). For example, tobacco seed beds are planted and maintained in the same months when plastic is put out for rows of tomatoes. Tobacco seedlings and tomato plants are transplanted in March in a similar, labour-intensive way. In June and July, both tobacco and tomatoes are harvested by hand; and, in August, fields are cleaned up after harvests of both crops. Given the similarity of these plans, it is not surprising that many ex-shade producers decided to become tomato producers.

By means of these internalized plans or scripts, therefore, the Gadsden farmer does not have to make a million decisions; he or she knows *how* and *when* to plant and transplant tobacco seedlings, string plants, cure tobacco, and pick "pink" tomatoes. Eventually, this knowledge will be passed to a new generation as a "traditional" way of doing things. The plans and scripts that evolve then remain a part of the traditional way of life until the original conditions or sequence of activities of the plan is interrupted, or the desired goal is changed. To quote one Gadsden producer: "We weren't accustomed to the thought that (shade) tobacco was going out because it had gone through cycles all the time, and we were not entirely sure that it wasn't going to come back; and we hated to lose the entire organization if it was possibly going to come back." This farmer cut tobacco production but continued growing the crop and losing money for 3 more years before stopping production entirely.

The importance of a plan or script as a tool in farming-systems research and extension is that it tells the investigator something specific about the person or group of people carrying out a particular action sequence. Plans are the highlights that show the outsider the insiders' methods to achieve their goals and satisfy the roles that place them within their culture.

Hierarchical decision models

A knowledge of farmers' traditional cropping plans or scripts, however essential to an FSR/E team designing on-farm trials, does not always tell the team what happens when the script or plan is interrupted or the desired goal is changed. A knowledge of farmers' decision criteria and perceived alternatives and options is, therefore, necessary to a team that wants to design adoptable technology or evaluate technology already generated.

With this information, they can build models of the decision-making process that incorporate farmers' decision criteria and constraints. The models of decision-making are hierarchically (Gladwin 1976, 1980) ordered on the basis of the characteristic to be maximized, incorporating alternative branches based on the constraints and criteria of the farmers. As Shoemaker (1982) noted:

> . . . most decisions are made in *decomposed* fashion using *relative* comparisons. Evaluations of multidimensional alternatives are seldom holistic in the sense of each alternative being assigned a separate level of utility. It is cognitively easier to compare alternatives on a piece-meal basis, i.e., one dimension at a time. . . .

Hierarchical decision models (HDMs) are decision "trees," flowcharts, lists, a set of rules, etc. For example, alternative money crops (Fig. 2) for shade producers in Gadsden would be hierarchically ordered on the basis of an activity's similarity to growing shade tobacco. The decision-maker mentally moves through a series of options that begin with those that are as close as possible to shade in managerial style and use of resources of land, labour, equipment, and capital and end with the option that is the most dissimilar to shade growing — that is, livestock, mainly beef cattle. Tomatoes, nursery crops, flue-cured tobacco, fruit orchards, pole beans and squash, and confinement hogs are similar to shade tobacco in that they are labour-

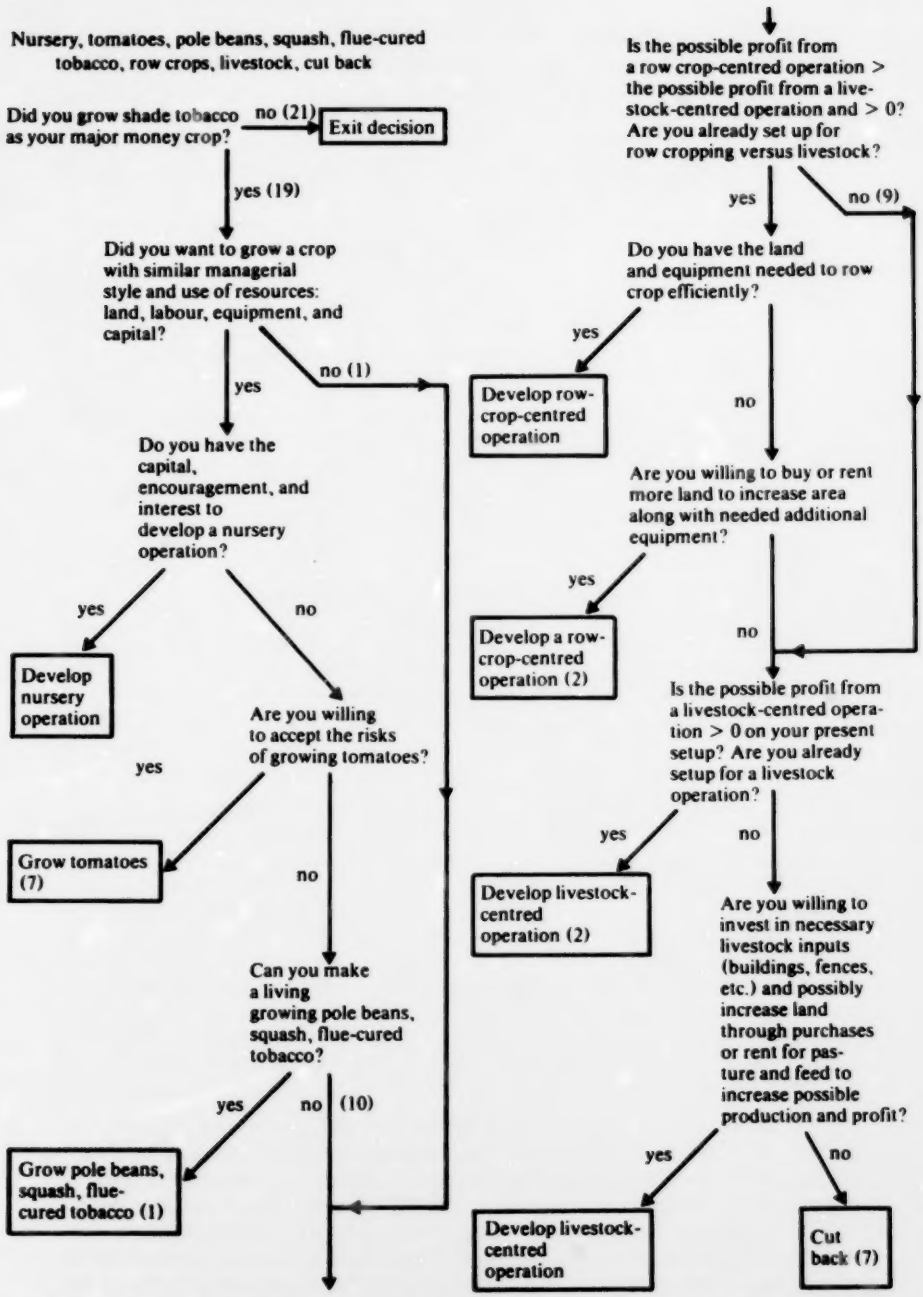

Nursery, tomatoes, pole beans, squash, flue-cured tobacco, row crops, livestock, cut back
Did you grow shade tobacco as your major money crop?
no (21)
Exit decision
yes (19)
Did you want to grow a crop with similar managerial style and use of resources: land, labour, equipment, and capital?
yes
no (1)
Do you have the capital, encouragement, and interest to develop a nursery operation?
yes
Develop nursery operation
no
Are you willing to accept the risks of growing tomatoes?
yes
Grow tomatoes (7)
no
Can you make a living growing pole beans, squash, flue-cured tobacco?
yes
Grow pole beans, squash, flue-cured tobacco (1)
no (10)
Is the possible profit from a row crop-centred operation > the possible profit from a livestock-centred operation and > 0? Are you already set up for row cropping versus livestock?
yes
no (9)
Do you have the land and equipment needed to row crop efficiently?
yes
Develop row-crop-centred operation
no
Are you willing to buy or rent more land to increase area along with needed additional equipment?
yes
Develop a row-crop-centred operation (2)
no
Is the possible profit from a livestock-centred operation > 0 on your present setup? Are you already setup for a livestock operation?
yes
Develop livestock-centred operation (2)
no
Are you willing to invest in necessary livestock inputs (buildings, fences, etc.) and possibly increase land through purchases or rent for pasture and feed to increase possible production and profit?
yes
Develop livestock-centred operation
no
Cut back (7)

Fig. 2 Decision tree for tobacco farmers forced by economics to change production activities: alternatives are denoted at the top; outcomes are in boxes; numbers of farmers choosing a particular branch are in parentheses.

and capital-intensive and use less land than do other crops — important criteria because of Gadsden's small fields.

The criteria that would motivate farmers to choose an activity that is less similar to shade tobacco include a change in goals (such as wanting to avoid the hassles involved in hiring migrant, seasonal labour) and lack of resources (such as not having enough capital to invest or to take the risks involved in marketing an alternative crop). Row crops like soybeans, corn, wheat, and peanuts that require relatively more land than labour or capital input become the options. If the requirements (economically efficient quantities of land, access to equipment, etc.) are beyond the resources of the farmer or if the profitability of raising livestock is perceived to be greater than row-crop production, a livestock-centred farming system would be chosen. Using more land and less labour and capital than tomatoes or row crops, beef-cattle systems as alternative "money crops" resemble shade-tobacco production very little and are the last option or suitable substitute for shade tobacco. Without a major source of income, the farmer has to cut back production or go out of business entirely, a decision related to "structure" issues described elsewhere (Gladwin and Zabawa 1983).

Knowledge of the decision criteria that farmers consider important (riskiness, capital-intensity, equipment and land requirements) is vital for a team trying to identify a suitable substitute money crop, as is a knowledge of their plan or script. Further, it is knowledge that cannot be picked up for all possible substitute crops on a "quick and dirty" 5-day reconnaissance survey (Franzel 1983; Gladwin 1983); it requires a follow-up survey using careful procedures to elicit information from farmers in a systematic way (Gladwin 1979a).

Using HDMs in technology evaluation

Although decision trees are most appropriately used at the *diagnostic* stage of a farming-systems research program to describe farmers' plans and explain farmers' reasoning and logic in using traditional practices, they are also useful in the testing stage, to evaluate technological packages ex-ante, i.e., before they become official recommendations of an institute or centre (Ashby and de Jong 1980). Examples of ex-post evaluations of a technological package 7 years after the design stage are given by previous evaluations of the Pueblo Project in Mexico (Gladwin 1976, 1979a, b) and so do not require further explanation here.

An example of an ex-ante evaluation via decision-tree models, however, can be taken from a project sponsored by the Florida legislature to increase the pounds of beef sold by Florida cattle raisers via an increase in the finishing and slaughter of cattle in Florida (Baltensperger et al. 1982). The project was multidisciplinary, including economists, agronomists, animal scientists, and extension agents. A beef-cattle package, developed by the Institute of Food and Agricultural Sciences (IFAS), was to be compared with traditional beef-cattle systems in northwest Florida, an area considered particularly important because of its ability to support cool-season pastures and produce other crops used as cattle feed.

One portion of the research focused on farmers' beef-cattle systems and farmers' decisions whether or not to use recommended practices (such as

controlled breeding, worming, and implantation of growth stimulants) in a cow–calf operation. In addition, farmers' traditional choice of a cow–calf operation over a "stocker" operation was studied, where stockers are calves that are bought as weanlings and "backgrounded," i.e., brought to weights high enough to "finish" them in a feedlot.

Some beef-cattle producers in northwest Florida did not use controlled breeding, i.e., limiting the length of the season to 3–4 instead of 6–8 months. Controlled breeding is a key recommendation upon which efficient exploitation of other recommendations depended. For example, implantation of growth stimulants depends upon a short, predictable calving season. Yet a large minority of producers did not impose a limited breeding season on their herds, perhaps dooming the entire IFAS "package" to failure or at least to only limited success. Finding out the reasons for nonadoption was the means for determining whether anything could be done to improve the potential for success of the program (Gladwin 1976, 1979a, b).

Each of the criteria in the decision-tree was a factor limiting adoption mentioned by the producers (Fig. 3). Indeed, of the 10 producers who could have used a controlled-breeding program but did not, 5 stated that they were satisfied with the present calving rate and saw no need to improve it. According to another farmer, controlled breeding would not improve the calving rate. Two additional producers stated that they did not have enough pasture to separate bulls and cows. One producer lacked know-how, whereas another wanted a consistent cash flow from the operation spread over the year.

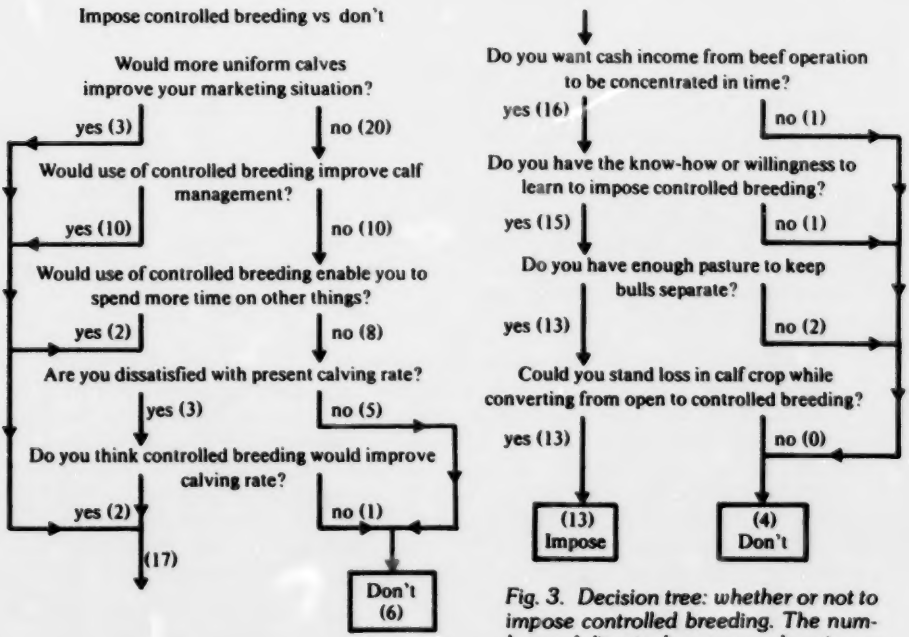

Impose controlled breeding vs don't
Would more uniform calves improve your marketing situation?
yes (3)
no (20)
Would use of controlled breeding improve calf management?
yes (10)
no (10)
Would use of controlled breeding enable you to spend more time on other things?
yes (2)
no (8)
Are you dissatisfied with present calving rate?
yes (3)
no (5)
Do you think controlled breeding would improve calving rate?
yes (2)
no (1)
(17)
Don't (6)
Do you want cash income from beef operation to be concentrated in time?
yes (16)
no (1)
Do you have the know-how or willingness to learn to impose controlled breeding?
yes (15)
no (1)
Do you have enough pasture to keep bulls separate?
yes (13)
no (2)
Could you stand loss in calf crop while converting from open to controlled breeding?
yes (13)
no (0)
(13) Impose
(4) Don't

Fig. 3. Decision tree: whether or not to impose controlled breeding. The numbers of livestock owners choosing a particular branch are in parentheses.

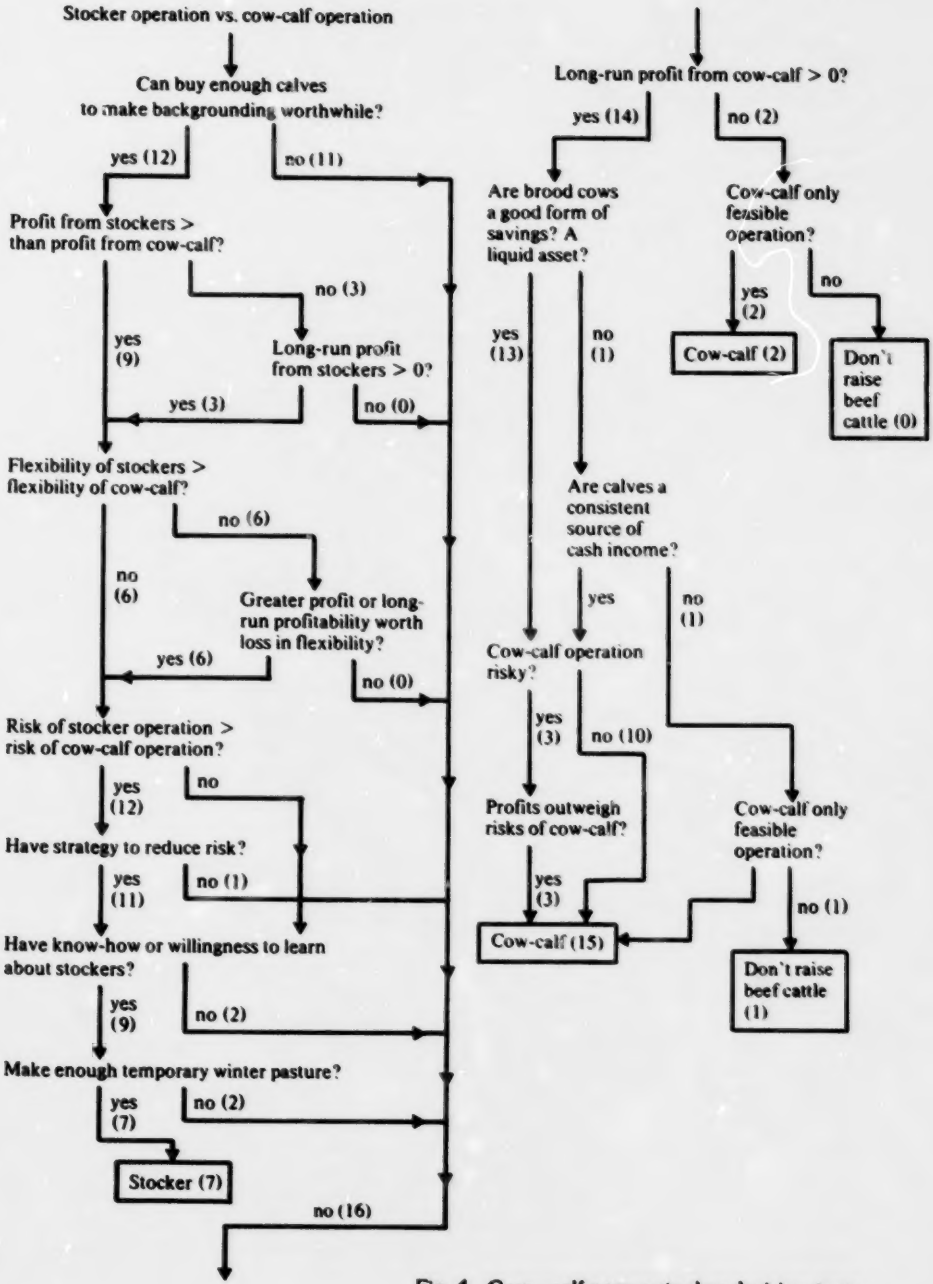


Fig. 4. Cow–calf versus stocker decision tree; numbers of farmers choosing a particular branch are in parentheses.

A decision-tree was also used to determine why some profit-oriented cattle raisers sold weanling calves rather than holding them till they reached the weight considered suitable for a finishing program. In Florida, as in other southeastern states, raising stockers — backgrounding — is potentially more profitable than owning a cow–calf herd (Ross et al. 1983), but, as the decision tree (Fig. 4) showed, it has some disadvantages as well. Also, there were key advantages to cow–calf herds that are overlooked in a simple examination of budget data.

First, size is a barrier to entry to backgrounding and, therefore, must be considered first. It is a barrier because returns/animal are small and marketing costs/animal, especially hauling animals to and from the farm, increase as the number of animals decreases. Several farmers claimed that hauling fees with less than half a truckload of animals (i.e., 25–30 animals) are excessive. Another disadvantage to backgrounding is that it is risky. Because stocker prices fluctuate more than weanling prices during a single year and weight gain — the critical factor in a successful backgrounding program — depends on variable weather conditions, the risks in raising stockers are greater than those of a cow–calf operation. Some farmers are not willing to assume the greater risk.

Disadvantages inherent in backgrounding are not the only reasons that more backgrounding does not occur. There are also requirements for successful backgrounding. A producer must know how to run a successful operation. Obviously, animal nutrition and health needs are important in this regard. Most producers, especially those with a farm background, have a reasonable understanding of these needs, and producers originally lacking this knowledge can obtain it easily from a number of sources. Marketing know-how is another matter. There are two marketing aspects related to the management of a stocker herd. First, the right kind of animal must be purchased; second, the animal must be sold. The former is critical as animals that will gain weight efficiently are keys to success. The ability to purchase such animals has been described as a learned art and is not just "picked up." Being able to produce an adequate supply of temporary winter pasture is also critical. If a producer has a winter backgrounding program, he or she must be able to produce such pasture in a timely fashion to get good weight gains. Thus, producers must ask themselves whether they have enough time, proper machinery and equipment, and know-how to plant combinations of rye, ryegrass, oats, and clover. If the answer is no, winter backgrounding is not an optimal choice.

Besides greater profitability, the stocker operation also has the advantage of greater flexibility. In stocker operations, the producers can change the size of their herd to satisfy anticipated market conditions and available time and pasture. In contrast, the cow–calf herd operators invest a good deal of time and management in a breeding program, trying to develop a brood cow herd that does well under the conditions of their farms. They are reluctant to sell part of their breeding stock in a bad year and decrease herd size. Similarly, increasing herd size in the short run is more difficult to the cow–calf operator, because finding the "right" brood cows or raising heifers of good quality is a long-run proposition.

On the cow–calf branch of the tree, profit in the long run rather than the short run is satisfied. Cow–calf operators, more than stocker operators,

justifiably believe they will lose money for approximately 3 years while starting up the operation. While heifers mature, management experience is gained, and a production system is established, they lose money. In contrast, stocker operations lose money maybe for 2 years while managers gain experience and establish a production system. The question for both would be: Can I sustain such losses?

As viewed by the producers interviewed, a cow–calf operation does have some advantages. Because brood cows are owned for more than a short time while income is generated from their calves, the cows are viewed as a form of savings. They can also serve as collateral on loans as well as a source of capital. Another advantage is that the calves can be sold at almost any stage in their development, whereas stockers should be kept until they reach a profitable weight. Even under the most constrained conditions (e.g., calves are held until weaning and controlled breeding is used), calves are available for sale for 3–4 months compared with a few weeks for stockers. Further, the potential sale period of calves when controlled breeding is *not* imposed is approximately twice as long. Thus, there is greater potential for more consistent cash income from a cow–calf operation that does not incorporate controlled breeding. Cow–calf operations, however, are not necessarily profitable. Nor do all producers find the advantages of a cow–calf operation to be attractive. Yet, some have brood cow herds, because they think that beef cattle are the only or the least-cost way to use the land and not lose their agricultural tax exemption.

Results showed that only 7 of 23 farmers decided to raise stockers, whereas 15 decided on a cow–calf herd. Limiting factors to potentially profitable backgrounding operations in north Florida included:

- Capital to buy a sufficient number of calves;
- Know-how to run a stocker operation;
- Riskiness of a stocker operation; and
- Ability to make enough temporary winter pasture to get good gains on stockers.

In conclusion, profit-motivated small producers who do not have the cash or credit necessary to buy enough calves for backgrounding opt for the less-risky cow–calf alternative. Producers with enough credit or capital accumulated to buy stockers will do so only if their cow herd will not suffer from competition with stockers for scarce resources such as winter pasture. Given these decision criteria, it is understandable that the traditional beef-cattle production system of the limited-resource farmer in north Florida is a cow–calf operation without controlled breeding.

Conclusion

This paper has presented examples of the use of ethnoscientific tools and hierarchical decision models in programs designed to generate appropriate technology for small-scale family farmers through a multidisciplinary team effort. In designing on-farm trials, farming-systems researchers can benefit from knowledge of farmers' indigenous classification systems, plans or scripts, and cropping decisions. The case of Gadsden County in the 1970s, when full-time farmers had to switch from shade tobacco to tomatoes

or go out of business, and the case of Gadsden today, when some farmers are trying to switch from risky tomatoes to other cold-weather vegetables, shows the utility of an in-depth knowledge of how farmers make cropping decisions and plans. Hierarchical decision models are also applicable in both ex-ante and ex-post evaluations of technology generated by a research team. Such evaluations are most useful, however, ex-ante — in the testing stage of the project. At all stages of farming-systems research and extension, an ethnoscientist has a more important role to play than that of "trained observer" (P. Hildebrand, personal communication). Specifically, decision modelers have a role to play in helping the team in an FSR/E program, and not just policy planners in an FSIP program, understand traditional farming systems, in contrast to conclusions reached by Hildebrand and Waugh (1983).

Farmer–researcher dialogue: reflections and experience

Michel Benoit-Cattin, *Institut de recherches agronomiques tropicales et des cultures vivrières, Montpellier, France*

I feel that the objectives of this book should be defined clearly in a large context, so that everyone will be aware of the scope and limits of future reflections. The meeting that gave rise to this book is closely related to two earlier workshops organized by ICRISAT: in 1974 (ICRISAT 1975) and in 1979 (ICRISAT 1980). Technical concerns dominated the first, but socioeconomic aspects were discussed. Only two contributions had significant anthropological content. The second one focused on socioeconomic constraints in the development of semi-arid agriculture, and a sociologist working in agricultural research in Senegal foresaw the route that farming-systems research is taking. His paper on farmer's participation put forward many ideas about involving farmers in research programs (Faye 1980).

Changes in farming-systems research have resulted largely from the growing involvement of social scientists in agricultural-research institutions and the consequent exchange between them and agricultural scientists. This book shows the predominance of social scientists who have an interest in the subject.

The issues have no geographical specificity (Agriscope 1983). They concern every state where the rural family is the major producer of agricultural goods. I believe that research and development efforts must interact continually with the environment they aim to improve.

Beyond undifferentiated approaches

My remarks stem from an attempt to analyze the institutions and individuals concerned with relations between farmers and researchers. Farmers, extension personnel, and researchers are all manipulated to some extent; they are all working in geopolitical settings that they may not fully understand but that largely predetermine their behaviour. Consequently, when we as researchers "tune in" to farmers, they may take advantage of the opportunity to press for fertilizer, credit, subsidies, etc. They assume that we are part of the government agricultural apparatus and think we can pass their demands on to the appropriate authorities. In fact, there is some basis for their assumptions. After all, areas in which farming-systems programs are funded and implemented are not selected solely on scientific grounds.

This is only one of many misunderstandings that arise in relations between researchers, development personnel, and producers (Tourte and

Billaz 1982) — the RDP triangle. (Although the triangle is a convenient simplification, I believe, it is more practical and less misleading to speak of rural societies, research, and interventions.)

Rural societies, research, and interventions are all social organizations. Each implies diverse, restrictive, heterogeneous, and nonegalitarian social structures. Perceiving this is essential for anyone involved in farming-systems research; it precludes an undifferentiated approach. It also obviates the "paradise-lost" way of thinking that rural environments were formerly in equilibrium and that this equilibrium was recently disturbed and must be regained. Researchers or others working with farmers must be aware of the complexity of rural societies. Just to observe a village meeting can be enlightening: there are rules for who sits where, who says what, and so on. Outsiders meet the local authorities rather than the "farmers."

Likewise, research activities cannot be separated from their institutional nature: whether they are funded and undertaken by national or international agencies; what role the countries and the agencies play in North–South relations; etc. Isn't there currently a qualitative change in these relations: a move away from policies for the transfer of technology and knowledge toward policies of support provided by established, well-endowed research institutions in the North to younger institutions in the South?

The institutions are diverse: they include government departments (agriculture, rural development, animal husbandry, the environment, education, health, trade, and so on); marginal government sectors (such as rural administration, which is based on a naive view of rural society that ignores the intricacy of local authority); sectoral- and integrated-development projects or activities; and nongovernmental organizations (NGOs), most of which have religious origins (CERES 1983). Although NGOs and government institutions have an interest in coordinating their activities, both inherently have their own status and objectives. This is also true of the individuals involved. Each researcher is strongly influenced by his or her special interest or discipline and may be unwilling (unable?) to share insights with someone from another field.

Individuals and institutions

The heterogeneity in rural societies — the contradictions and conflicts — has come to light through ex-post analyses and surveys. To understand it completely, one must compare what is reported with what is observed. Thanks in part to this method, my colleague and I (Benoit-Cattin and Faye 1982) were able to differentiate individuals' objectives and conducts according to their status in farming operations in the Sahelian Sudan. Such analyses can have concrete effects. For example, one who understands the farm-equipping process could draft costed proposals for organizing the manufacture and distribution of equipment for an entire region. The fact that all heads of households, for diverse and even contradictory reasons, wish to possess all that they require for farming with draft animals (animals, seeder, multipurpose hoe, cart) can be used for a simplified trend analysis. Censuses make it possible to project the demand over the medium term and meet this demand as far as possible, given the capacity to produce the tools and the financial constraints arising from the distribution of the tools on credit.

Scientific research precedes, accompanies, supports, and clarifies assistance policies. Not that these contributions overshadow the social responsibility of research to attain long-term results and expand knowledge. Research must have a balanced orientation toward technical innovations, rural societies, and assistance policies. Researchers from the disciplines most directly concerned must be able to share findings, value their colleagues' perspective, and interact in an ecological, geographical, and political context that has yet to be defined.

Looking at practices

The men and women in rural societies work mainly at growing crops and raising animals but also do many other things. All these activities must be considered in terms of the objectives, plans, and motivations of the individuals and groups. The purpose of analyzing practices is to define and understand the systems in use for production, crop growing, animal husbandry, forestry, and so on.

The methods proposed for finding out what farmers are doing are increasing (Benoit-Cattin 1979a; Billaz and Diawara 1981; Benoit-Cattin and Faye 1982; Agriscope 1983), and most rely on a mixture of interviews and observations. This mixture ensures that reported practices are compared with actual practices. The information supplied by farmers must not be confused with their interpretations. Where organization of work is concerned, social "rules" elicited by outsiders talking to farmers no longer reflect how things are done. Practices vary from one farm to another, depending on how much equipment the farmers have and how long they have had it.

In assistance policies, too, statements of intention often diverge widely from practices. A country's agricultural policies as stated in a development plan are often quite different from policies in force. Moreover, the principles behind an agricultural-development project sometimes differ profoundly from extension practices.

The task of identifying problems and designing programs to address them is complex; it depends on what is vaguely called social demand, as well as on the strategies of institutions (their internal scientific directions). The present vogue of farming-systems research exemplifies the complexity. One constantly hears that an interdisciplinary approach is required; in practice, a multidisciplinary approach — that is, a parallel approach by the disciplines — is used. There has been debate over whether the procedure is downstream or upstream, most farming-systems researchers finally being satisfied to call it circular. Can the notion of circularity be applied meaningfully to systems?

One experience

In Senegal, rural agricultural-research activities — known as experimental unit projects (Benoit-Cattin 1977a) — were begun in 1969 in two cooperatives in the south. For about 12 years, a great variety of specialists worked together or succeeded each other on the sites. The push to agronomically improve the real environment intensified research into such areas as anthropology, nutrition, training, economics, sociology, and extension (Benoit-Cattin 1979).

The results were knowledge, description and analysis of the situation, improved methods, and a series of proposals to national and regional authorities responsible for agricultural development. Since 1977, farm counseling has been under way, a genuinely interdisciplinary effort drawing on the project agronomist (who may be considered principally an innovation promoter), the economist (who focused on farm performance and development in a context of technical change), the sociologist (who had acquired a keen understanding of local social dynamics by working on land-tenure problems), and all field personnel — extension workers and survey officers (who were the real links between researchers and farmers).

The steps in the farm-counseling method are selection of interested farmers, with preference being given to those with serious difficulties; assessment by the extension officer; design of a proposal aimed at medium-term progress on a farm; negotiation with the farmer to refine the proposal; and implementation of the program year by year with provision for adjustment (Benoit-Cattin 1978).

Through the experience gained from the first farm-counseling efforts, rules have been refined and adapted. At the same time, knowledge has been increased, and farm operations have been improved.

The function of farm counseling is technical; both the researchers and the farmers evaluate technologies as experienced technicians. After all, throughout history, agricultural techniques have been invented by farmers and not by researchers, who have come on the scene only recently. The technical function is complemented by an economic evaluation of farm conditions. From this analysis, standards are determined (such as one seeder for every 5 ha or a debt limit of one-third of the head farmer's income). It is also complemented by a social and cultural framework for introducing innovations on farms. This framework provides the basis for the rules. For example, one complete set of cattle-powered equipment is proposed for each farm, plus one set of implements for every other household (Benoit-Cattin 1977b). To establish farm counseling, one must learn how local farms operate and how techniques are adopted. One difficulty encountered was that the extension workers' status with respect to farmers was brought into question. The workers found it difficult to accept that they were no longer regarded as the ones with the knowledge of the techniques and that they had to take farmers' views into account during negotiations. To speak of farmers as colleagues in technical research indicates that they must be awarded equal status in the efforts.

Nevertheless, farm counseling must not be perceived to be merely a structure used by researchers and farmers; it is also a structure for agricultural extension. Moreover, it is the source of concrete proposals to those responsible for agricultural policy (Benoit-Cattin 1978).

Defining production units for research: an experience in Upper Volta

Michel Braud, *Institut de recherches du coton et des textiles exotiques, Paris, France*

The major aim of my work at IRCT is to propose operational tools on a meaningful scale, that will initiate dialogue with the major development partners, from the national level down to the individual plot. The population and environment chosen are as representative as possible so that the results, whatever they may be, can be extrapolated.

The unique aspect of this work is that there have been virtually no tools designed specifically for it. Some imagination was, thus, required to use the available data in a practical manner. An example is IRCT's work with the Bobo-Dioulasso Hauts-Bassins regional development organization (ORD).

Environment

First, the environment, which can be perceived at levels ranging from the region to the plot, was recently zoned. The work consisted of defining intermediate regions through an analysis of all available ecological, technical, social, and economic data. The Hauts-Bassins ORD region is almost exclusively within a region that has been labeled intermediate II, in which cropping systems are tied to cotton growing. At first glance, the agrarian system appears homogeneous.

The Hauts-Bassins ORD took a major step by developing a means of collecting data at the production-unit level. My colleagues and I assisted in finding practical ways to use the data. We are also seeking a better understanding of actual cotton-growing conditions by, among other things, attempting to establish a production-unit typology.

We selected 26 indicators for this typology. By using computerized data analysis, we were able to identify 8 different types of production unit (Table 1). We found a great deal of heterogeneity at the level that might be considered to concern the farmer most (Fig. 1), and for that matter, the region, which had been considered homogeneous, also proved geographically heterogeneous (Fig. 2).

Without having conducted extensive studies, we have amassed and analyzed information on a farming environment. Cooperation has been the key. Nevertheless, the investigation phase involved extensive analysis, and the primary concern was that the samples be representative. This lay the groundwork for the second phase — intensive analysis — which focused on

Table 1. Principal characteristics of 8 types of production unit in Hauts-Bassins ORD.

	Type							
Indicators/100 units	1	2	3	4	5	6	7	8
Population	640	609	772	645	1525	1133	863	1119
Working-age (>15 years) population	320	312	368	377	742	475	424	521
Draft animals	73	7	11	21	208	42	226	333
Plows	43	2	6	12	83	17	95	92
Cotton-treating machines	23	12	15	14	67	33	55	121
Cottonseed yield (kg/ha)	1933	1248	189	647	842	233	1113	1194
Use of animal traction (%)	27.6	10.0	3.0	12.4	43.5	7.2	57.5	62.7

case studies. To complete the picture, one needs chronological data to take into account the variability of the environment in terms of its two major components: ecology and economics.

Case studies

The principal aims of the methods involved in the case studies were to regard a farming system as a research station operating in real conditions to achieve a certain number of objectives with limited means, within constraints

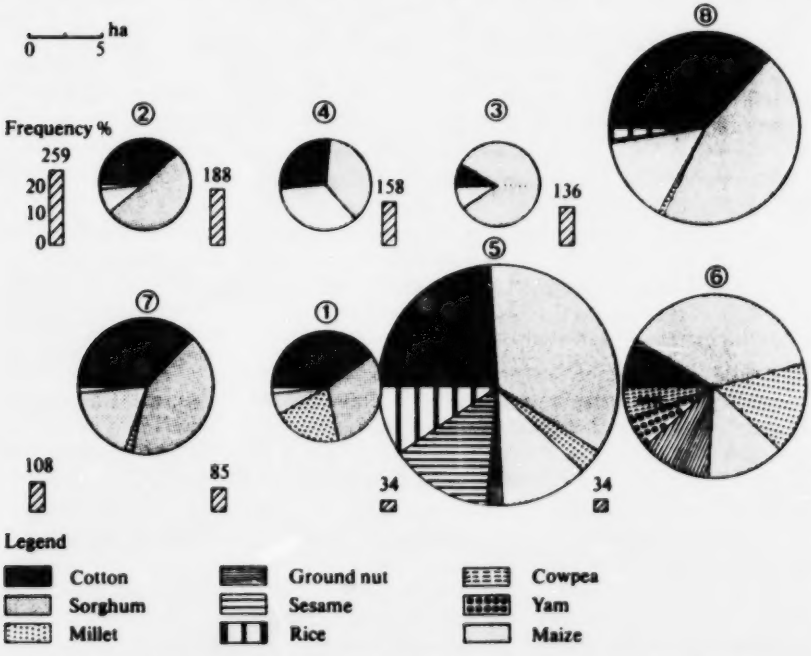


Fig. 1. Classification of the 8 farming-system types by decreasing order of importance, proportion of farm area, and 1981 crop rotation.

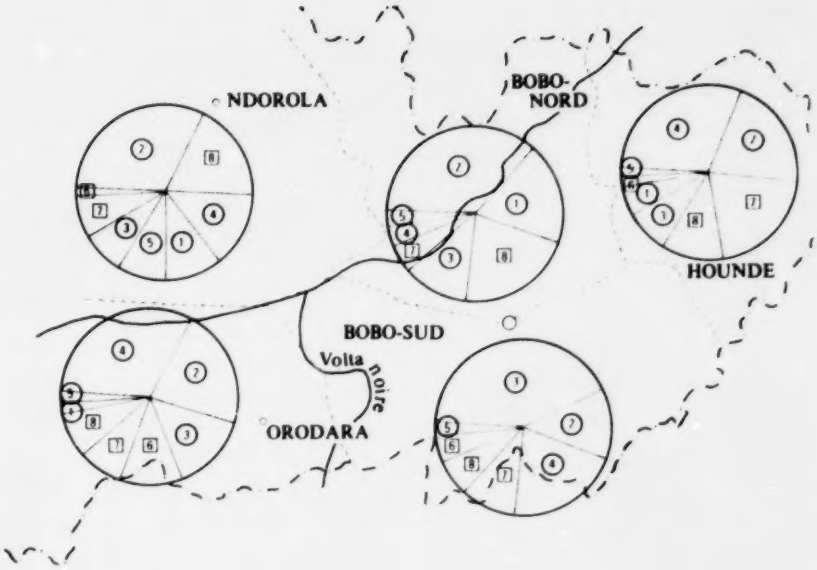


Fig. 2. Geographical distribution of production units by sector.

that are diverse and often unpredictable; to collect information in the most basic form to avoid biased interpretations and provide answers to the questions of who does what, when, where, how, and why (the last question probably being the most important because it involves causality and goes beyond description); to involve the farmers directly or indirectly in this activity and initiate dialogue based on the farmers' knowledge, their logic, our own logic as researchers, and, perhaps, the discoveries we will make together; and to use automated means, in particular microcomputers, to process in a reasonable time the large volumes of data collected.

We began by studying the selected production units' structures, available means, and production intentions. The data gathering required participation by the farmers or literate members of their family who were trained in the use of standardized vocabulary and notation concerning the activities to take place during the research. The standardization permitted computer processing of all data without coding, which causes delays and, at times, errors. The idea was to have the maximum amount of processed information available when required for the activity.

After two trials in the Central African Republic and Mali, the program was extended to Upper Volta as a test of the methods. Given the limited computer facilities available to the team in Upper Volta, I can report only a portion of the work under way on three farms in the ORD's Houndé sector. The farms have distinct structures: one uses manual labour, another uses animal traction, and the other has motorized equipment.

Data collected must always be perceived by researchers as a means to carry on dialogue with the farmers. For example, the data concerning labour

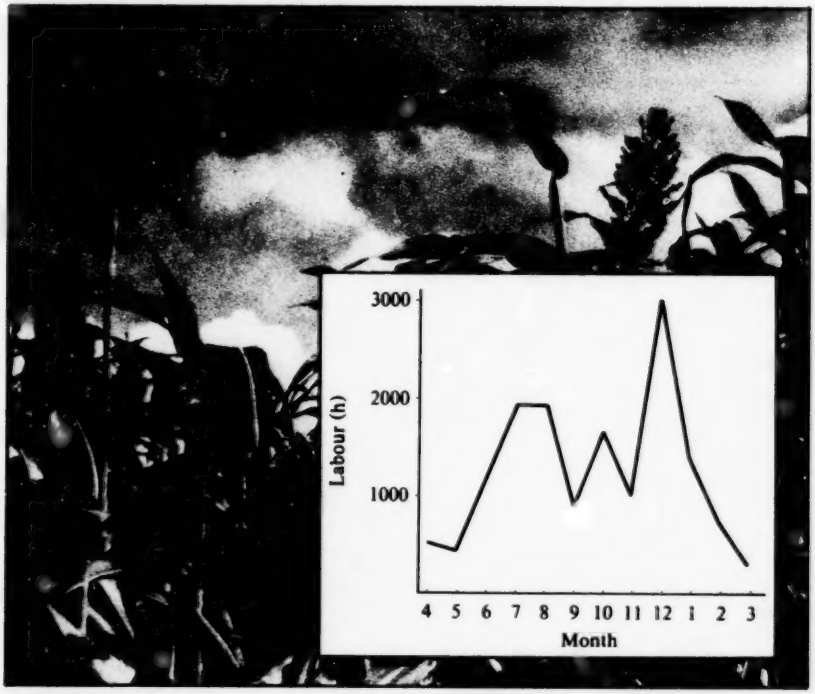


Fig. 3. Total labour use by month. Sorghum production, which is a component of all eight cropping systems, demands about 6% of the total, mainly for weeding and harvest.

(Fig. 3, Table 2) indicated clearly the relative dominance of maintenance and harvesting. How do the farmers perceive the dominance? What are the consequences? One can carry the analysis to the plot level — of cotton production, for example — still focusing on labour data. On one farm, six plots were cultivated during the crop year. The weeding time varied in a ratio of 1 : 8, indicating the great variation possible in one type of farming activity and for one crop. The variability is the product of real rather than

Table 2. Labour use (h) by crop, activity, and type* of worker.

	Cotton				Maize				Sorghum				Groundnut			
	M	W	C	O	M	W	C	O	M	W	C	O	M	W	C	O
Seed bed preparation	236	104	225	380	160	73	70	—	33	—	25	—	6	—	12	—
Seeding	71	67	94	—	40	33	13	—	17	35	3	—	10	61	10	—
Fertilization	33	52	24	—	16	42	60	—	—	—	—	—	—	—	—	—
Weeding, crop management	834	641	1029	—	205	102	402	—	79	—	279	—	20	18	27	—
Insecticide applications	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Harvest	786	769	559	1841	336	359	180	146	88	48	14	—	109	92	51	80

* Type of worker: M = man; W = woman; C = child; O = outsider.

experimental conditions and provides valuable answers about the system's environment. The reasons for the variability may be diverse and include such things as the previous crops grown on the plot, the type of soil, the preparation of the seed bed, rainfall, available technical resources, and social factors. Similarly, harvesting time is in a ratio of 1 : 5.

By extrapolating this type of observation to the entire agricultural operation, using the collected data, one can determine the technical agendas for each crop and each plot. This information allows one to ascertain the objectives, the farmers' means, and the diverse constraints. The dialogue should provide researchers with an understanding of the farmers' logic and the background necessary for both groups to work together: a joint researcher–farmer effort based on the information collected and aimed principally at identifying cause-and-effect relationships rather than describing the situation. This can produce a preliminary list of problems and, in some cases, solutions to the problems.

On-farm activity must be preceded by research or experimentation in a controlled environment. At each step, one should attempt as complete an evaluation as possible so as to increase the possibility of extending the results for development. No standard tool is relevant to all cases. For example, the introduction of a new variety differs substantially from the introduction of a herbicide. They have different impacts and risks.

The impact of a new variety is modest in relation to that of other production factors. For example, the two major effects for cotton are, first, variation in production of, perhaps, 10% and, second, variation in risk as determined by the hardiness of the new variety. These effects are more significant at the industrial level, from the ginning plant to the oil mill to the spinning mill, than at the farm level. A very simple approach is to introduce the new variety on a small strip 10 m wide and 100 m long, for example, located between two identical strips for comparison purposes. The quantity and quality of the yield are measured on all three strips for corresponding technological analyses, and the farmers' reactions to the new variety are recorded on a questionnaire. This type of innovation is of little concern to the farmer.

In the introduction of herbicide, the researchers' and farmers' concerns are much greater. There are technical aspects at the plot level, including heterogeneity within the plot, soil preparation, the skills involved in herbicide application, modifications of treatments with corresponding side-effects, effects on succeeding crops. Other considerations are inputs available in the system (applicator and product); reliability and organization of supply; as well as economic factors such as cost of equipment and product, equipment operating costs, and labour requirements. Also, the herbicide must be applied on a scale large enough to ensure that observations are not skewed, especially concerning work time. The usual proposal is to divide the farmer's plot into three equal parts and introduce the innovation on the middle section.

Conclusions

The activities I have described are part of a process involving all levels of agricultural systems, from the national to the individual. The extent to which

the various partners and research disciplines are involved depends on the level concerned as well as the research stage. The common denominator for everyone must be the farmer.

If this condition is met, one can focus on the diverse data that are needed to reinforce the frame of reference and ensure it is both representative and consistent. However, the rural environment is profoundly variable. This means that basic changes in working methods are required. Most importantly, models, which are based on too few variables and are much too prescriptive, should be abandoned. A good initial instrument, in my opinion, is a typology that identifies the most pertinent criteria for directing development proposals. This approach has increased the likelihood that IRCT will be able to respond to farmers' real problems and limits the risks involved in extending solutions.

This paper was prepared with the help of Célestine Belem and Michel Berger (IRCT, Upper Volta), Alain Joly (IRCT, Montpellier, Biometrics), and Yeko Traore and Pierre Cochelin (Hauts-Bassins ORD).

Research design and implementation in the Sebungwe Region of Zimbabwe

Malcolm J. Blackie, *Department of Land Management, University of Zimbabwe, Harare, Zimbabwe*

Zimbabwe has a productive but strongly dualistic agricultural sector. Approximately 5000 large-scale farmers produce some 94% of marketed agricultural output and support directly about 1.8 million Zimbabweans. These farmers occupy 1.66×10^7 ha of land (known as commercial farming areas), predominantly on a freehold basis. By contrast, the remaining farming areas produce only some 15% of total measured agricultural output, while providing subsistence for about 4.5 million people (Chavunduka 1982). These latter (known as communal farming areas) cover some 1.63×10^7 ha and are occupied by smallholder producers under a variety of traditional tenure arrangements.

In the early days of European settlement in Zimbabwe, agricultural production was an important source of income for black small-scale producers (Palmer 1977). Within a decade of the first major influx of settlers, discrimination in terms of access to markets and land progressively debilitated the capacity of the smallholder sector to compete with the emerging large-scale agricultural sector. In consequence, by independence in 1980, many commercial lands were at a low level of agricultural productivity. Since independence, an important element of agricultural policy has mobilized the unexploited potential in the commercial areas (Blackie 1982).

The communal farming areas of Zimbabwe typically lie in the less favourable agroecological regions. They exhibit considerable diversity in terms of resource availability, human populations, and infrastructure. The failure of successive governments to devote resources toward developing the lands has resulted in a marked and increasingly critical decline in the productivity and welfare of the inhabitants. This paper describes work initiated by the Department of Land Management at the University of Zimbabwe in a region containing some of the least-developed communal farming areas in Zimbabwe.

The research program undertaken by the university has three objectives:

- To expand the on-farm field research and training capacity of the university. The program is intended to assist the university in making a major contribution to on-farm research development in Zimbabwe and in setting up community-based programs.
- To contribute to the training of experienced field agriculturalists. Zimbabwe currently faces a critical shortage of agricultural scientists with experience in operating independently in the field, in controlling

staff and budgets, and in directing and coordinating research. The program is aimed at providing an environment in which young qualified Zimbabweans can acquire the skills necessary for the expansion of the national agricultural research system into the communal farming areas.

- To foster effective linkages between the university, farmers, and development agencies.

Before independence, most agricultural scientists were trained in South Africa, with an orientation primarily to serve large-scale farmers. The University of Zimbabwe played a minor role in the support of the agricultural sector. Following independence, the demands on the university to produce graduates trained to meet the needs of the Zimbabwean agricultural sector have increased substantially. The Department of Agriculture at the university has been upgraded to a faculty with major increases in staff, budgets, and student intakes. However, if the university is to support national policy and address the problem of increasing productivity from the communal areas, it needs to establish its own clientele among smallholder producers. There exist, in Zimbabwe, well-established research and extension services and the need was not to duplicate work undertaken by these agencies but to complement and support their activities.

The program has been designed to evolve through two phases. The first phase, which is the subject of this paper, involves the collection of baseline data and the definition of priority research. The second phase will involve the design and implementation of pilot projects. The phases will not be strictly sequential; experience elsewhere suggests that there will be considerable interaction between the two phases. The overall concept draws heavily on the experience with caqueza in Latin America (Zandstra et al. 1979).

The Sebungwe region

The Sebungwe region (Fig. 1) lies in northwest Zimbabwe and extends southward from Lake Kariba. The region is administered by four local government district authorities, notably Binga, Gokwe, Kadoma, and Kariba. Government services to the region are provided by three provincial authorities: Mashonaland West, Matabeleland North, and Midlands. The region is 3.66×10^4 km^2, of which 69% constitutes communal farming areas, 17% the National Parks and Wildlife Estate, 9% freehold smallholder farms, and 5% forest areas. Infrastructure throughout the region is poor, with large areas of inaccessible rugged terrain occupied mainly by wildlife. Tsetse fly occurs through much of the region, and agriculture is based primarily on subsistence farming. Where cattle are precluded by tsetse infestation, hand-hoe cultivation is the norm.

Before 1956, few people lived in Sebungwe. However, since that date, population in the region has expanded enormously. First, the valley Tonga, who traditionally farmed the alluvial soils along the Zambezi river, were forcibly resettled because of flooding of their homes after the construction of the Kariba Dam in 1957. Some 21 000 people on the Zimbabwe side of the Zambezi were resettled in this exercise; all were relocated in the northern part of the region (Scudder 1982). Second, a program of both voluntary and compulsory resettlement in the southern part of the region was commenced.

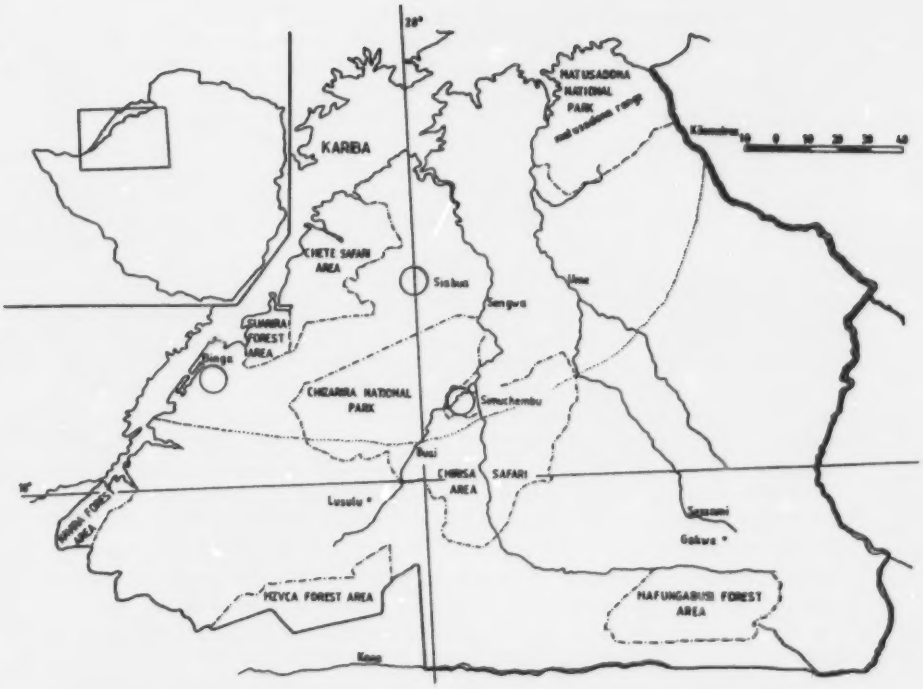


Fig. 1. The Sebungwe Region, Zimbabwe, is the focus of a farming-systems development project.

The volunteer settlers came from overcrowded communal lands in other parts of Zimbabwe. Political activists were forced to settle in the area before independence in 1980. Today, the population is about 304 000 people, and the estimated population growth rate between 3.3 and 3.6% annually (Falkenhorst 1983).

The research program described in this paper deals mainly with the peoples of the northern part of the Sebungwe. The valley Tonga occupy the areas with the poorest infrastructure and agricultural development potential. A further forced resettlement of these people is unlikely to contribute to their welfare so that it is essential to improve the productivity of the areas they currently inhabit, although voluntary resettlement may provide a partial solution in some cases. Studies of low-income communities throughout the world that have been forcibly resettled show the majority of the people concerned to be worse off during the transition period. This period is rarely shorter than 2 years and may last a whole generation (Coulson 1971; Hansen and Oliver-Smith 1982). Scudder (1982) observed a strong contrast between the Zambian and Zimbabwe sides of Lake Kariba. In Zambia, resettlement was accompanied by a major tsetse-control program, together with substantial investment in educational facilities, fisheries development, and appropriate agricultural research. In Zimbabwe, before independence, the authorities did not develop the infrastructure or invest in the region. The valley Tonga now occupy an area of markedly different, and lower,

Table 1. Estimated crop yields in the Sebungwe region, 1979–80 (kg/ha).

	Gokwe	Binga	Kariba
Maize	1238	364	546
Sorghum	792	300	546
Edible beans	446	—	—
Bulrush millet	619	137	273
Finger millet	628	—	—

Source: Second crop forecast, 1979–80 season, AGRITEX.

agricultural potential than their traditional homes and have endured a quarter century of neglect. The outcome has been apathy and dependence (Scudder 1982).

Land zoned for use in agriculture accounts for 78% of the total region. Most agricultural development, however, has been confined to the southern parts, mainly because of tsetse infestation in the north. However, the available data suggest that there are only 2.0×10^3 km² of high-potential arable land and 5.0×10^3 km² with medium potential; the area of low potential is 9.0×10^3 km² (ARDA 1982). These data are derived mainly by interpretation from geologic and vegetation mapping, and no extensive soil surveys are available.

The evidence from Zambia suggests that these data seriously underestimate the agricultural potential of the area. There is, therefore, a need to undertake field verification of the existing data base so as to arrive at a scientifically sound estimate of agricultural potential.

Crop yields are typically low (Table 1), and the last two seasons have seen an almost total crop failure in the northern part of the Sebungwe. Inputs, such as fertilizer and agricultural chemicals, are not easily available. The light soils that characterize much of the area are susceptible to erosion and are of low fertility. In the tsetse zones, the cultivated area per family is about half that in the tsetse-free areas, thus further compounding the production problems of families (Falkenhorst 1983).

With the exception of the capital-intensive, large-scale Sanyati scheme in the south of the region, there has been virtually no irrigation development. Falkenhorst (1983) reports some 26 plot holders on 8 ha of irrigated land in the entire region.

Zimbabwe has been zoned into five regions of differing agroecological potential, with regions IV and V being defined as suitable only for extensive livestock production (Table 2). The Sebungwe lies in natural regions IV and

Table 2. Livestock numbers in the Sebungwe region, 1981–82.

Area	Cattle	Pigs	Sheep	Goats	Donkeys
Binga					
Manjolo	18000	400	4000	25000	1000
Siabuwa	82	61	1200	700	16
Gokwe					
Gokwe	152000	4000	18000	108000	17000
Kadoma					
Sanyati	16000	133	46	5000	108

Source: Department of Veterinary Services.

V (with the exception of small areas of natural region III around Gokwe village and Chisarira National Park). The official livestock-marketing system deals almost exclusively with cattle for slaughter. In the farming systems of the area, cattle are so important for draft power that they are rarely slaughtered or sold, with sales being about 2–6% of the herd. This contrasts with an offtake of 15–20% in the neighbouring commercial farming areas (Blackie 1983; Jackson, Blackie, and de Swardt, forthcoming). Field data from the present season indicate negligible sales of other livestock, although an offtake of about 10% of the goat flock could materialize if marketing facilities were available.

The region also includes some 6.07×10^3 km^2 of wildlife and safari areas. Falkenhorst (1983) estimated the revenue from hunting accruing to the district councils in the region in 1983 as Z$331 000 (Z$1 = US$1). Because of the poor access roads and facilities, the number of tourists viewing game is insignificant except in Matusadona National Park in the northwest. The national parks in the Sebungwe have been running at an increasing deficit since 1979 (Falkenhorst 1983). The interaction between wildlife and agriculture has also caused increasing friction between the farmers, the Department of National Parks and Wildlife Management, and the safari operators. Elephants persistently raid crops, particularly in areas contiguous to wildlife reserves. Poaching of game to supplement food supplies and also for income is common.

The research agenda

Because the Sebungwe is an area of low agricultural productivity, it offers major technical and socioeconomic challenges to agricultural researchers, and a unique opportunity for the University of Zimbabwe to initiate an interdisciplinary research program, aimed at mobilizing agricultural development in the region. The evidence from Zambia suggests that the overall potential of the area is much greater than conventionally assumed in Zimbabwe. Although official development agencies are active in the region, field officers are faced with considerable problems in operating in large, remote areas with little research support. The production systems of the region are poorly understood, and the agroecological potential varies widely. There is little technology that has been adequately tested in the region, and empirical data on production constraints are almost totally absent (Weinrich 1977; ARDA 1982; Scudder 1982). The university's participation in the development of the area was, therefore, perceived by most government agencies as complementing their work. At a recent seminar on development in the region, a senior government official responsible for development commented (Mudenda 1983):

> . . . we are happy today to see the beginning of a close association in development through recent attempts by the University to explore the agricultural potential of Binga district in particular and the Sebungwe region in general. This giant step in development has been taken by the University three years after our independence and a quarter of a century since its inception. . . . Through [the efforts of the Faculty of Agriculture] we hope the people of Binga will acquire agricultural skills which will enable them to feed themselves . . . and produce surplus food for

Typical Tonga homestead in the Sebungwe Region, Zimbabwe.

> sale. . . . But let me caution . . . against purely considering Binga district as a guinea pig research station. The results of research must flow into practical development of the area in spite of the fact that these results do take a long time to collate and publish. Our research must be development orientated even if . . . from the pursuit for academic excellence.

The initial impetus for the university involvement in the Sebungwe came from two sources. First, the Department of Land Management had been surveying small-scale cotton producers south of Gokwe village since 1980 and was already involved in on-farm research in the region. Second, the Agricultural and Rural Development Authority (ARDA) held a workshop, which I attended, in 1982 to review the current state of knowledge regarding the area (ARDA 1982). The workshop revealed major deficiencies in data required for planning in the region as well as an absence of suitable technology for agricultural development.

Two alternative strategies for the development of the region emerged from the workshop. The first, the wildlife strategy, was based on the assumption that the agricultural potential of the region was totally inadequate to support its human population. The economy of the region should, therefore, be based on the sustained harvest of its wildlife resources. The inhabitants of the area would rely mainly on the processing of game products, sale of handicrafts, and subsistence agriculture for their income. The capital for the social infrastructure of schools, clinics, and roads would be generated from safari hunting and tourism. The second strategy, the agriculture strategy, assumed unexploited agricultural potential. Agriculture was identified as the sole major source of income capable of supporting the increasing population at a reasonable standard of living (Scudder 1982; Falkenhorst 1983). Following the ARDA workshop, the Department of Land Management expanded its research in the region in cooperation with

government agencies involved in planning and development activities. The outcome was a research agenda linked directly to priorities identified by the inhabitants of the Sebungwe and by the various government authorities involved in development.

In August 1982, I undertook an extensive reconnaissance survey with assistance from Thayer Scudder who, together with Elizabeth Coulson, had undertaken a long-term study of the valley Tonga in Zambia, commencing just before the construction of Kariba Dam (Coulson 1960, 1971; Scudder 1962; Coulson and Scudder 1975; Scudder and Coulson 1979, 1980). The survey had no formal structure beyond a geographical focus on the Sengwa River basin. In planning the survey, we realized we had neither the time nor the resources for a comprehensive coverage of the region. Thus, we decided to enter the region through Gokwe village and follow one of the major rivers, the Sengwa, down to Lake Kariba. Lack of water forces people to congregate along the large rivers, and most agricultural production is on the alluvial soils bordering these rivers. The Sengwa also runs through and alongside important wildlife and forestry areas. This strategy, therefore, allowed the investigation of conflicting land- and water-use systems and development opportunities throughout the river basin. The survey was undertaken mainly by road, with stops of several days being made in various key areas. Scudder (1982) described the survey procedure:

> Throughout the field trip, our procedure was to discuss Sebungwe problems with as many people as possible. Whether travelling by land or water, we were constantly stopping to talk with people we met along the way, including those asking for lifts and those we sought out in fields, villages, stores, schools, fish camps, safari camps, hotels and government offices. In this way, information was systematically collected from several hundred people including farmers, fishermen, school children, teachers, storekeepers, safari and hotel operators, chiefs, district councillors and government officials. Discussions were also held with officials in Harare during March, July and August, 1982.

The preliminary survey helped define the research agenda. It confirmed my impression from the ARDA workshop that there was an appropriate and useful role for the university to play in the development of the region. It also demonstrated that agricultural development should be the top priority in the region. The survey enabled me to obtain a clear understanding of the differing perspectives on development priorities held by farmers, government officials, and the private sector (primarily safari and hotel operators and storekeepers). The research agenda could be planned in the light of first-hand experience of the logistical problems of operating in a remote, poorly serviced part of the country. Finally, Scudder provided valuable input for the research agenda, drawn from experience of the successes and failures on the Zambian side of Lake Kariba. The preliminary agenda was to:

- Determine appropriate dam sites for water development and irrigation through air-photo interpretation combined with ground survey where indicated;
- Identify from Lake Kariba charts and aerial photographs appropriate areas for recessional cultivation, grazing, and fisheries development;
- Consult geological maps of the Sebungwe vegetation maps and aerial

photographs to identify the arable soils that could be subject to more detailed soil surveys;

- Assess the agricultural productivity of the Siabuwa area, which has been cultivated for generations by the densest population within the northern Sebungwe. Surveying the potential and constraints for agricultural development would provide valuable information on the fertility of the entire range of shales that occur extensively throughout the Sebungwe;
- Survey the nature of the valley peoples' production systems at the household and community level in different areas;
- Investigate the potential for wage employment for local people within the Sebungwe region and in the adjacent townships of Hwange, Kamativi, and Kariba;
- Survey marketing practices for goats, turkish tobacco, and other local produce and introduce pilot marketing schemes;
- Form development strategies for specific areas in which human activities currently conflict with park and game-management areas.
- Survey the health status of a carefully selected sample of village communities to improve programs of preventive medicine;
- Design surface and subsurface dams and pumping devices suitable to Sebungwe conditions; and
- Introduce on-farm trials of improved agricultural technologies.

The next procedure was to review this agenda with professional colleagues at the university, in appropriate government ministries, and in both national and international agencies involved in rural-development activities. The university had no previous experience of operating a major program of this nature. There were communication channels to be set up between the university researchers, farmers, and development agencies active in the Sebungwe. Practical, logistical, and technical problems were involved in operating remote from the university. Although the Department of Land Management could support some initial fieldwork, the extensive and long-term commitment required outside funding. Support at the top levels of both government and the university would be essential if the necessary resources for a sustained program were to be sought. The policy adopted was to invite participation from other researchers at the university within the guidelines of the research agenda. The first step was to initiate some relatively straightforward projects involving the study of the basic resources of the area and to develop, from these, more complex and comprehensive exercises.

An open seminar on the research agenda was hosted by the Department of Land Management. From this seminar came indications of interest in collaborative research from several university departments, and I requested detailed proposals. Five submissions were eventually agreed upon:

- Reconnaissance land resource survey; involving an appraisal of the soil and water resources of the region using aerial photography supplemented by selective studies of soil and water, the survey would yield information on areas of arable potential and also on the potential for small-scale irrigation in the region;
- Production and marketing survey; providing an inventory of the main income-earning and subsistence activities of farmers in the region, this

The Tonga settlements totally lack infrastructure.

study would be linked to a farming-systems survey to identify major production constraints and to consumer surveys in neighbouring urban areas to determine the market for produce grown in the Sebungwe;

- On-farm trials of improved sorghums and millets, testing for suitability and farmer acceptance under Sebungwe conditions;
- Goat-production and management study, collecting data for a goat-improvement strategy and a pilot goat-marketing scheme; and
- Study of the household economy of gillnet fishing villages; examining fish consumption and sales as well as how they affect the household

An open-air school in the Zambezi valley.

economy of families in the region, the study would enable better planning with regard to the exploitation of the fish resources of Lake Kariba to the benefit of the local inhabitants.

These proposals were budgeted and then discussed in detail with senior government officials at the national, provincial, and regional levels as well as with the Binga district council. (For practical reasons, it was decided to site most of the initial work in Binga district.) The proposals were modified and then were submitted to external agencies for funding. Support was obtained from Ford Foundation, the International Development Research Centre (IDRC), the United States Agency for International Development (AID), and the University of Zimbabwe Research Board. Without adequate funding, the defined research agenda would have benefited neither the university nor the farmers.

The field program

With funding secure for the first year's fieldwork, the senior researchers involved visited the sites in which one or more of the studies were to be conducted. These were Simuchembu, Siabuwa, and Binga. Simuchembu lies about 300 km west of Harare and 100 km north of Gokwe village on the Sengwa river. It is a salient of agricultural land lying between Chimsu safari area and Chizarira National Park and, thus, is an area of land-use conflict between the agricultural and wildlife agencies. Siabuwa is some 50 km north of Simuchembu, on the other side of Chizarira National Park. It lies on the main road linking Harare and Binga and is about 70 km inland from Lake Kariba. Binga is 400 km west of Harare and 300 km north of Bulawayo and is situated on the shore of the upper reaches of Lake Kariba. Siabuwa is one of the most densely settled areas in the Sebungwe and has the longest history of cultivation. The infrastructure comprises a stone clinic and school as well as two small irrigation schemes in the vicinity of the settlement. Binga, likewise, is, for the region, quite well developed. It is the administrative centre of the Binga district and has the main government offices as well as a secondary school, clinic, and rest camp. More importantly for this project, as the settlement is on the lake, fishing is an important part of the local economy. Accompanying the university group was the provincial agricultural officer, the regional agricultural officer, the extension supervisor for the area, and the extension worker responsible for providing assistance and guidance to the farmers at the selected sites.

At each site, one or more villages would be involved in the research program. The extension worker called a meeting and the villagers met with the university party. At the meeting, the government agricultural staff introduced the university group and explained that the university was coming into the area to assist with agricultural development. The members of the university team then made a formal presentation to the meeting. This involved:

- An explanation of what the university was and why it wished to do research in the area;
- A description of the various study projects including a detailed exposition on materials and data to be collected and their use in the research; and

- A careful statement on the likely outcomes of the research and how the results could be used for development purposes.

Each meeting lasted several hours and involved detailed discussion on the choice of research topic and the program to be followed. In some instances, alternative research areas were suggested, and reasons for excluding such alternatives at this stage were given and debated. All cases either had been part of the initial research agenda or were topics impractical for university research at present. Research into cattle for draft power was a top priority at all the meetings, but the sites lay within tsetse-control areas, and regulations prohibit cattle. Until cattle restrictions were lifted or modified, such research would be impossible. However, the priority of this topic was noted for the future. In all cases, the proposed research was supported by the local residents. The timing of the field program was then outlined as well as any particular requirements for local support such as the hiring of field assistants.

The university is now in the early stages of the first year's fieldwork. All the studies have been initiated and the response from the communities directly involved has been most encouraging. The research, even at this early stage, has involved the farmers actively. An example is the production and marketing survey. At each site, the intended procedure was to interview formally a sample of some 40 farmers and then to conduct informal questioning of farmers selected randomly in their fields and homesteads, starting with Simuchembu and moving later to Siabuwa and Binga. The Simuchembu survey was conducted in September 1983, but I realized quickly that I would have to interview all farmers who presented themselves. The use of sampling techniques was unfamiliar to the local residents and could have provoked mistrust. Although some farm-management detail was lost from the survey (some 320 farmers presented themselves for interview), the outcome was a minor agricultural census of the site and included data on single women and widows. These last groups are easily missed in a sample survey. The essential data on production strategies and crop mixes have been collected, and the informal questioning after the formal survey appears to have bridged most of the gaps in the data.

The first year's fieldwork is intended to provide data sufficient for the program to begin introduction of new technologies. This step will be fully discussed with the farmers and their support sought. The link between the survey work and the choice of new technologies will be carefully explained. The communities will have to become familiar with the concept of sampling, as introducing a technology on a comprehensive basis is clearly impractical and undesirable. The intention is to familiarize the communities with the fundamentals of experimental design. The results of the fieldwork will be explained and the next stage outlined. The experimental design will, inevitably, be a compromise between scientific and local requirements. This collaboration is fundamental to stimulating input from the producers into the design and modification of new technologies.

The intention, therefore, is to involve the farmers actively in the entire process. The university is operating in a remote and difficult region with a small staff. There are no permanent university field facilities except for a research station on the shores of Lake Kariba accessible only by boat. Unless the communities and government field staff cooperate fully in the research,

an effective development-oriented program will be difficult to sustain. Much of the work to date has involved careful and systematic setting in place of the appropriate research agenda and the associated channels of communication. The coming season will test the feasibility of the approach.

Conclusions

The concept of research on small farms is novel in Zimbabwe. The Department of Land Management has, since independence, supported this approach to developing agricultural technology appropriate to the communal farming sector. The involvement in the Sebungwe provides a framework for a larger, interdisciplinary effort on the part of the university into on-farm and community studies. The program has enjoyed farmer input from the outset. The research agenda derived from the initial reconnaissance survey was heavily influenced by the views of the communities within the Sebungwe. The geographical logic to this survey played an important part in ensuring that the research agenda was realistic and reflected the priority needs of the region. As the agenda was pruned to a subset of topics manageable by the university, the counsel of senior local residents and officials was regularly sought.

The outcome was a set of research studies that fitted both the abilities of the university staff interested in working in the Sebungwe and the defined priorities of the region. The proposed implementation is designed to encourage further farmer participation. Although there remains much to be learned (and, no doubt, mistakes to be made), the enthusiasm of both the communities and the university and government staff is encouraging and bodes well for the future.

Accenting the farmer's role: Purdue Farming Systems Unit

Mahlon G. Lang and Ronald P. Cantrell,
Farming Systems Unit (Purdue University)/Semi-Arid Food Grains Research and Development Project, Ouagadougou, Upper Volta

We shall describe, analyze, and evaluate our experience with farming-systems research; we believe the information is valuable because modifications in our approach have substantially increased the role of the farmer in the process.

Principal considerations in the design of research are the objectives and the allocation of resources to meet the objectives. The emphasis in the objectives ranges from one extreme in which the principal concern is to institutionalize farming-systems research in the national program to another extreme in which the concern is with the rigour and sophistication of the research. Proponents of the latter extreme may view institutionalization as a secondary objective or one that is attainable only in the distant future.

Whatever the goal, credible, multidisciplinary investigation is essential to its achievement. At Purdue University's Farming Systems Unit, a primary concern is to design a research method that can be adapted as part of a national program. This goal forces us to forego complex data management and analysis in favour of simple and useful research that is readily adaptable to settings where skills in data management and analysis are limited.

Between the 1982 and 1983 cropping seasons, we made significant changes in our approach. Although, during 1982, we achieved the goal of conducting multidisciplinary research involving farmers to design new technology, we concluded that our method needed to be modified if it were to be adopted by national programs.

Given our concern with the design of an adaptable method, we believe we have moved much closer to an optimal allocation of scarce research resources. Specifically, we have:

- Increased the role of the farmer in the research;
- Increased the contribution of our Voltaic field staff;
- Increased flexibility for multidisciplinary and Voltaic participation in the design and conduct of farming-systems research;
- Increased the number of villages studied; and
- Increased the number of farmer-managed field trials.

These increases have been achieved with the same resources used during the 1982 cropping season. The major casualty in the reallocation of research dollars was the collection of labour data throughout the cropping season.

Initial approach

Four types of socioeconomic data were collected during 1982:

- A census was taken in three study villages. Random samples of 60 farms were drawn from two villages, and a sample of 90 farms from the third. Detailed household and agricultural resource data (active workers, draft animals, and equipment) were collected from each household in the samples.
- Labour times and nonlabour inputs were recorded on a biweekly basis for all agricultural activities on each farm. For 150 of the farms, data were collected for all activities on all cereal fields and on at least one field of each other crop. For the other 60 farms, data were recorded for five farmer-managed field trials.
- Decision-making interviews were conducted by the economist with at least 30 farmers in each of the three villages. These explored the farmers' goals and objectives, factors affecting their resource-use decisions, and their assessment of binding constraints to increased production.
- Field sizes and yields were measured for all fields for which complete labour data were taken. Yield was weighed, and grain production was estimated from the percentage of grain remaining after a 10-kg sample was threshed.

By far, the most demanding of the four activities was the collection of labour data. This required 90 of the hours worked by 12 interviewers throughout the growing season.

The other major activity was agronomic research employing two types of on-farm field trials. At the direction of four agronomic assistants, a farmer-managed millet trial with five treatments was conducted by each of 30 farmers in each village. The themes of these trials were low-dose applications of rock phosphate (100–200 kg) and urea (50 kg) and water conservation using tied ridges. In addition, eight researcher-managed trials were conducted in all three villages. These trials included varietal, fertilizer, and water conservation themes for corn, sorghum, and legumes.

Principal findings

Highlights of the findings were that:

- In two villages on the central plateau, and in half of the sample village on the edge of the plateau, the farmers are clearly oriented toward subsistence. They claim to ignore price in cropping and in deciding when to sell their crops. Their sales are strictly residual, prompted only by "urgent need" regardless of the market price. If, as harvest approaches, their stocks are adequate, they sell grain to purchase small ruminants, which are kept for sale during lean years. The data documented the farmers' reliance on livestock sales as a principal source of revenue to purchase grain. Thus, the farmers are not, by plan, part of the cash economy.
- Although the principal grain crop in all three villages is millet, farmers would like to plant more sorghum because sorghum stores twice as

long (3–4 years) as millet (1–2 years) and, during good years, yields more than millet. They plant less than desired quantities because the variability in yield of sorghum and, therefore, production risk are much higher than those associated with millet.

- Labour, as has frequently been observed in other studies, is often a binding constraint during the first weeding but is slightly more available during the second weeding.
- Millet plantings are highly and consistently correlated with the number of active labourers/household. Sorghum plantings are confined to land that is more fertile or has better water retention.
- Use of draft animals is profitable in the land-abundant zone because of intensification effects and on the central plateau where extensification is possible. On the plateau, no intensification effects were detected.
- In two villages, the farmer-managed millet trials showed statistically significant ($P<0.05$) yield responses to phosphate in the seed pocket and to tied ridges. The most promising treatment was a combination of the two techniques. For one village, average yield increases easily covered cash costs and provided returns to labour of about 28 CFA/work hour.

The implications for the design of appropriate technologies are that:

- Noncommercial farmers resist the use of purchased inputs;
- In the absence of increased fertilizer applications, continuous cropping with cereals leads to poor-quality soil. Increased plantings of millet relative to sorghum are probable because labour, the only variable input, can be used to produce millet on marginal land.
- If the farmer were to use cash inputs, they would probably be for a preferred crop like sorghum.
- A shift to increased sorghum production would require that its yield variability be reduced or that expected yields be increased sufficiently to compensate for cash risk associated with purchased inputs.
- The use of nonpurchased inputs should be maximized so that cash risks associated with low-dose applications of fertilizer are minimized.

Taking this information into account, the agronomist chose to add sorghum and corn experiments to the farmer-managed trials for 1983. Because of the soil quality, the agronomist found that small doses of purchased fertilizer would be essential in sorghum trials. As a nonpurchased input, labour would be used during the second weeding to build tied ridges for water retention, the aim being to offset the cash risks associated with the use of chemical fertilizers.

The tied ridges would also be used in corn trials. Because the yield variability (risk) associated with corn is high and because corn is already planted in relatively fertile soil, no fertilizer would be used in the trial.

Whether these trials prove successful remains to be seen. What we find important is the research approach that permitted us to combine agronomic and socioeconomic findings in choosing these trials.

The agronomist and economist worked with the farmers to arrive at a

choice of farmer-managed trials for 1983. The steps in the process are noteworthy:

- The agronomist gave the economist an initial assessment of the agroclimatic environment: rainfall is as high as that in other regions of the world where much higher millet and sorghum yields are achieved. The problem is erratic distribution of rainfall over the season. Soil fertility and water retention are low. The soil has little organic matter, and some chemical fertilizer is needed for improved yields. Phosphate is relatively inexpensive and locally available but urea, which is essential, is more expensive.
- The economist suggested trials on millet because it is the dominant staple crop. He conducted simple breakeven analyses on various fertilizer-application rates.
- The agronomist concluded that expectations for yield increases can justify only low rates of fertilizer application. To get response from low-application rates, he suggested putting phosphate in the seed pocket and discussed this with farmers to find an acceptable method of doing so.
- In lengthy interviews, 94 farmers described to the economist their goals and objectives, factors affecting their cropping decisions, and their production constraints.
- The agronomist assembled results of field trials.
- The economist estimated hours required to apply each technology.
- The agronomist analyzed results of farmer-managed field trials on millet. The trial using both tied ridges and phosphate in the seed pocket was the most promising. A repetition of the trial was planned so that the residual effects of phosphate and the effects of water conservation from tied ridges in the early season could be measured.
- The economist concluded that, for the average participating farmer, the yield increase from use of tied ridges and rock phosphate would easily cover cash costs. He observed that risk is the critical factor in evaluating the trial. In spite of gains in the arithmetic mean yield, the distribution was skewed, and 50% of farmers would have lost cash. Residual effects of fertilizer and tied ridges would be critical to the adoptability of this technology.
- Farmers discussed farmer-managed trials with the agronomist. One trial (tied ridges and phosphate in seed pocket) was of interest. Some claimed they would do it again. At the beginning of the 1983 season, the farmers told the agronomist they see the effects on soil and water conservation of tied ridges and do not have to draw lines for planting because they can use the ridges that were built the previous year.
- The agronomist evaluated researcher-managed trials.
- Based on interviews with farmers and tests of hypotheses generated by these interviews, the economist told the agronomist that the farmers are subsistence oriented; that they would prefer to plant more sorghum but, to reduce the risks of poor yields, would have to improve the quality of the land; that they would consider cash inputs for sorghum but that cash inputs would have to be minimized and noncash inputs — mainly labour — maximized.
- The agronomist decided that fertilizer could make "millet land" into "sorghum land" and that building tied ridges, which draws on

nonpurchased inputs, would reduce the adverse affects of drought and would offset the cash risk associated with fertilizer use. Researcher-managed trials on sorghum showed strong interaction effect of tied ridges and low doses of NPK fertilizer.

Implications for research

The sources of socioeconomic information most helpful in the design of trials were "one-shot" interviews that drew directly on the farmers' knowledge and on empirical data (household surveys, field and yield statistics). We were able to ask the farmers questions, generate hypotheses, and then empirically test the farmers' claims. For example:

- Our understanding of the farmers' orientation toward subsistence was developed through "one-shot" interviews. While subjective, these interviews were thorough, and the responses were internally consistent among farmers. (Empirical verification and objective measurement of the meaning of subsistence is a major objective of a repeated monthly survey being used during 1983.)
- Interviews also spelled out the risk-averse behaviour of the farmers — the decision to plant millet instead of sorghum in spite of the higher expected return and better storability of sorghum. (Empirical tests using 1982 yield data confirmed higher yields but statistically greater yield variance for sorghum than for millet.) The farmers' behaviour is consistent with subsistence farming. If farmers could afford to assume more risk, they would plant more of a preferred, higher yielding grain even if its yield were variable. Higher yields in good years would compensate the losses in bad years.
- The rules that farmers followed in making decisions about crops were derived from personal interviews and then tested using land-area and household-resource data collected on a one-time basis.
- During interviews, farmers said that the constraint on labour was binding at the first weeding and that labour was somewhat less constrained during the second weeding. (Analysis of our labour data showed results consistent with this claim. The peak labour week during second weeding is nearly as busy as the peak week during the first weeding, but the second weeding takes less time. Farmers do not hire labour for the first weeding primarily because it is unavailable.)

These findings have shaped our research program for 1983, with respect to both socioeconomic and agronomic research. Socioeconomic research is devoted to defining subsistence production and to estimating risk and the risk preference of the farmer. The agronomic trials incorporate considerations of subsistence, risk aversion, and the preference for more sorghum.

During 1982, the bulk of our research resources was devoted to the collection of labour data, the principal use for which is the modeling of representative farms. But the socioeconomic information found most useful in shaping the design of future trials was that secured th ugh "one-shot" interviews or objective data-collection efforts.

We are pleased with the quality of our labour data and believe that continued analysis of those data will also provide valuable insights for the

design of farm trials. Given the goal of developing a workable national program, however, continued investment in the collection of such data appears to be a misallocation of scarce research resources for several reasons:

- The sheer volume of data collected represented a massive task in data management: 6 months of skilled professional time was needed to "clean," enter, and verify data.
- Analysis using the data cannot begin until well after a cropping season is completed.
- Manipulation and analysis of large volumes of data are, in our experience, frequently delayed by power failures and breakdowns in computer hardware.
- Designing models is time-consuming and can only be done by experienced professional economists.
- The opportunity cost of such activity is high. Opportunities to conduct useful research on farmer behaviour are foregone each month that labour data are collected.

Meanwhile, the farmers are willing to answer a wide array of questions about how and why they farm the way they do. Their claims can be empirically tested, and the basic information about their resources and the way they allocate them is essential to the design of appropriate techniques. Farmer-managed trials also provide most valuable information not only with respect to the technical relationships between inputs and outputs but also with respect to the farmers' explanation of how the trial fits or does not fit into their cropping pattern.

Our experience in 1982 indicated that a broad range of information could be obtained from the farmers and tested by empirical data. It also indicated that crop risk and ownership of livestock were factors in the farmers' decision-making and should be a focus of research. The conditions that permit subsistence farmers to become active participants in the cash market are not well understood; the farmers' market behaviour and its relationship to food security, land, labour, and capital resources should be examined. An understanding of these relationships would permit one to determine the conditions under which purchased inputs may more readily become part of the farmers' cropping practices. Finally, our experience suggested that there is much to be gained from expanding farmer-managed field trials in the program.

Alternative approach

During 1983, labour times are being measured only on the farmer-managed field trials. Socioeconomic research consists of two monthly interviews. In the first, which is repeated every month, interviewers deal with 150 farmers (30 in each of 5 villages) recording complete monthly data on grain in storage, consumption, purchases and sales, trades, gifts given and gifts received. Farm-level prices and motives for transactions are also secured. Data are assembled by crop and by family member initiating the transaction. The same data are taken for livestock and poultry. The second interview has a variable theme. It may be different each month, or one theme may be pursued for 2 or more months. The questionnaire can be coded or open-ended. To November 1983, the themes have included varieties of seed

Table 1. Resource base for two approaches to farming-systems research.

	1982	1983
Agronomic assistants	4	9
Socioeconomic interviewers	12	5
Controllers	3	2
Professional and staff visits to villages/month	6	10
Field staff visits to head office/month	0	1
Questionnaires designed and analyzed	4	12

employed, advantages, disadvantages, years used, and reasons for changes (May 1983); estimates of nonagricultural sources of revenue for year and case studies of hours, expenses, and revenue from one specific activity by male and female members of the household (June 1983); marketing patterns, locations, motives, etc. of men and women (July 1983); farmers' goals and objectives (August 1983); noncereal food consumption by farm families (September 1983); and yield expectations of farmers (October–November 1983).

Land under cultivation and yield will also be measured because they provide empirical information needed to test hypotheses generated in discussions with farmers. Specifically, these data facilitate direct tests of land-use decision rules. Because we are no longer gathering labour data, the total interviews are fewer than in 1982, and we have been able to expand agronomic activity. Whereas 12 socioeconomic interviewers and 4 agronomic assistants worked in 3 villages during 1982, 5 socioeconomic interviewers and 9 agronomic assistants work in 5 villages in 1983.

A new feature in our approach is a monthly conference with our interviewers and agronomic assistants. Interviewers present to the entire staff a critical, qualitative assessment of the data they have gathered during the month. They also work with the data-processing personnel to explain "gaps" or inconsistencies in their data. Agronomic assistants present reports on crop progress and on particular problems faced by farmers in their zones during the month. Their reports add a qualitative dimension to the coded data and generate new and useful research ideas.

Using this approach, we believe we are accenting the activities that most helped us to achieve our objectives in 1982. Meanwhile, the 1982 labour data will be analyzed and we will be able to determine whether they tell us enough to justify collection. Given our resources, we could follow farmers' labour activities only during critical periods; otherwise, we would have to forego the opportunity to draw upon the farmers' knowledge.

The approach used in 1983 draws essentially upon the same resource base as that for 1982 (Table 1), but the research product is different (Table 2). In effect, the research outputs of the two approaches represent two points on a curve of research-production possibilities. If the goal is to institutionalize research that draws upon combined agronomic and socioeconomic inputs to shape future trials, researchers must choose among approaches that range from a nearly exclusive focus on the collection of cost-route data to a sole reliance on subjective interviews with farmers. The approach used during 1982 focused more on the collection of data needed to do modeling. The approach currently used draws heavily upon subjective information from farmers but retains a focus on the collection of objective, empirical data to test hypotheses generated through such interviews.

Table 2. Research product using alternative approaches.

Dimension	1982	1983
Villages studied	3	5
Farmer-managed field trials	1	3
Researcher-managed trials	8	7
Interviews/farmer	8/month	2/month
Variable-theme interviews	1/year	10/year
Number of farms on which complete labour data were collected	150	0
Number of field trials on which labour data were taken	90	340
Use of outside expertise in research design	Rare	Frequent
Professional roles for Voltaic staff	0	2
Farmer's role in socioeconomic research	Passive	Active, diverse
Interview's role in:		
Socioeconomic research	Repetitive	Variable theme
Interpretation	Nil, informal	Active, formal
Printed reports	Annual	Monthly
Multidisciplinary input opportunities	Close coordination in planning	Flexible
Feedback from agronomic assistants	Informal	Formal (status)
Feedback to technology design	Annual, indirect	Monthly, direct
Feedback to component research	Indirect	Direct

There remains a need for permanent survey instruments. Responses to certain questions are difficult to test empirically. Such questions require that we use "permanent" questionnaires to check on the internal consistency of attitudinal or qualitative data. However, such questionnaires "lock" up scarce research resources for an entire year. Reasons for committing scarce resources to such an approach must be compelling. We are collecting monthly data on stocks, transactions, and disposition of grain. These will permit us to measure the farmers' risk preference, the objective meaning of subsistence, and the conditions under which farmers become more commercial in their orientation.

We are increasing our reliance on "one-shot" research methods because:

- They introduce flexibility, with the potential for researchers to address economic, agronomic, and sociological themes. The expertise of professionals not on the field staff can be drawn upon, and national researchers can gradually assume leadership roles.
- They allow for researchers to draw more upon farmers' knowledge to formulate hypotheses, which can be tested empirically with data collected simultaneously, subsequently, or, if justified, in repeated interviews during the succeeding year.
- These were the primary sources of information used to shape agronomic trials during the previous year.
- The data can be rapidly processed and analyzed, with basic computer skills, and the maintenance of computer hardware is not critical.

Survey costs and rural economics research

John McIntire, International Crops Research Institute for the Semi-Arid Tropics, Sahel Center, Niamey, Niger

The recent vogue of farming-systems research in Africa among scientists, donors, and bureaucrats has arisen largely from their frustration at the slow progress of African agriculture. The fashion is sustained by the convictions that profitable technical packages exist, that scientists fail to exploit farmers' knowledge in research, and that existing methods increase research costs by unnecessarily extending the payoff period.

The conviction that profitable packages exist encourages governments and development agencies to search for effective ways to supply the techniques to farmers. The argument is that inputs to farmers, especially information as it is supplied by extension, are a sufficient and necessary condition for adoption of new techniques. The belief that scientists use farmers' knowledge inefficiently, notably by failing to understand farmers' objectives, explains much of the emphasis on village work and especially on doing more than demonstrations in farming-systems research. The argument about profitable packages partly explains the insistence on quick results because it assumes that many of the fundamental (i.e., long-term) problems have been solved. These influences give farming-systems research its principal characteristics: close link to extension; involvement of many disciplines (including social scientists); bias toward quick results; and prejudice against fundamental research.

Wealthy lobbies support farming-systems research strongly and, by implication, the assumptions upon which it is based. These assumptions determine how the lobbies spend their money and how this spending affects farmers. It is important, therefore, to understand the economics of farming-systems research, to relate its economics to its objectives, and to define efficient methods given costs and objectives.

This paper analyzes the costs of the two principal types of methods — intensive (emphasizing quantitative data collection and analysis) and extensive (searching for a qualitative understanding of the farmers' environment and their responses to it). I believe that the differences between the methods are smaller than the similarities and that there is some scope for combining them to exploit the virtues of both.

Intensive surveys

ICRISAT's economics program has used intensive surveys in India (since 1975), Upper Volta (since 1980), and Niger (since 1982). Small

numbers of villages — six originally in India, six in Upper Volta, four in Niger — are studied after a literature review and preliminary visits to identify suitable sites in different agricultural zones (Jodha et al. 1977; McIntire and Matlon 1981).

Field enumerators reside in the villages and visit samples of 25 – 40 households every 1 – 3 weeks. After censuses of people, fields, animals, and machinery, the regular interviews (sometimes known as cost-route interviews) are conducted on crop production, crop and livestock transactions, and transactions in inputs and in land, labour, and capital. In crop production, enumerators follow all inputs and outputs by plot. These data are complemented by special studies on, for example, soil fertility, millet marketing, crop by-products, and cowpea storage.

The short-term aim in these studies is to identify and to quantify variables limiting crop production. From village data, for example, we construct input – output tables of crop production. On the input side are flows of materials and primary factors; on the output side are flows of crops and by-products. Using the tables, we estimate productivity to guide technical research. Because the villages represent agroclimatic zones, the results can be extrapolated (whether immediately or by verification surveys) to other areas.

The long-term aim is to ask fundamental questions about the economies of the semi-arid tropics, answers to which can guide research allocation and policy. For the semi-arid tropics, such questions include: What is the magnitude of farmers' aversion to risk? What are the main determinants of mechanization? What role do markets play? What are the common nutritional deficiencies? How is income distributed? How do farmers respond to changes in supply and demand? How economically efficient are various activities?

Extensive surveys

Extensive surveys begin, as do intensive ones, by defining research areas by the principal exogenous variables in the farming system: rain, soil, altitude, and population density. Zones are then evaluated with rapid surveys of local conditions, such as cropping patterns, mechanization, and chemical inputs. More detailed, exploratory surveys are done (ideally in the cropping season) to verify the findings and to determine what the farmers consider to be the constraints within the zones. The results provide the basis for a set of recommendation domains on farming systems.

The approach is to describe, rapidly and qualitatively, the resources in a farming system, their allocation, and the constraints to their fuller use or to an increase in their productivity. The description is "qualitative" only in that the researchers do not attempt to measure precisely the endogenous variables in the system or to quantify the constraints. Rather, the approach provides educated estimates, from careful interchanges with farmers, of the boundaries for the treatments in technical experiments — for example, cycle length in varietal tests and fertilizer rates in agronomy trials. The boundaries for the variables define the domains for the tests.

Extensive methods have no long-term aim and are not geared to answering fundamental questions. Their proponents assert that the intensive

approach makes inefficient use of scientists' time, that farmers' needs are pressing, and that extensive methods sacrifice little important precision — "important" in respect to bias in trials designed from the results of extensive surveys.

Similarities

The methods agree about much. In fact, extensive methods are perfectly consistent with intensive ones, and, at ICRISAT, we have used them to identify research topics and sites. They agree on zoning to determine what constitutes a representative sample and to guide research allocation. The methods agree on the importance of farmers' knowledge, considered as a rational appreciation of the system and of changes in it. The methods agree on the necessity of a multidisciplinary approach. They share a systems approach; they view endogenous variables such as fertilizer use and mechanization as determined by exogenous variables.

The methods' agreement on the importance of farmers' knowledge implies, first, that the researcher will have to find out some of what the farmer knows, i.e., be directly involved (intensive methods have been accused of precluding this or minimizing it at any rate). Second, it implies that neither method can be described as upstream or downstream because both view farming-systems research as a circle, not a line, as is necessarily implied by notions like upstream and downstream. Whether one begins at the point on the circle where farmers define the problems or where researchers do depends upon the information available at the beginning of a research program.

The intensive and extensive methods differ mainly in how precisely they estimate endogenous variables and in how much importance they give to long-term aims. Advocates of extensive approaches do not deny that precision and long-term perspectives are important; they assert that the costs of greater precision and of more time spent on a single sample exceed the benefits and, therefore, that extensive methods are more efficient than are intensive.

Casting the debate between the two methods as one of the costs of precision in cross-section data and of quantity in time-series enables one to examine their relative costs.

Survey costs

I tabulated ICRISAT's long-term (5 years) survey costs from actual intensive surveys in Mali and Niger for 1982 and from budget requests for 1983 (Table 1). Similar budgets (Table 1) were produced for extensive surveys, although the figures were artificial in that the technical coefficients (e g., professional staff years/sample unit) were estimated from published accounts. Costs from Niger and Upper Volta were applied to the technical coefficients.

From published accounts of extensive surveys (CIMMYT 1978, 1980), I calculated the numbers of staff years in all categories necessary to survey a given number of households. Each number was multiplied by the number of scientists and then multiplied by its annual cost. The costs of local personnel

Table 1. Intensive and extensive survey costs (US$).[a]

	Intensive					Extensive	
	Upper Volta 1983	Niger 1983	Niger 1982	Mali 1982–83	Mean	CIMMYT 1980	Zambia 1978
Capital	7134	17368	13153	4972	10657	1707	1363
Variable	187333	122363	124022	28314	115508	93961	69003
Total	194467	139731	137175	33286	126165	95668	70366
Households	149	107	100	80		80	60
Area (ha)	866	1328	1328	800		NA[b]	191
Population	1604	1132	1132	800		NA	300
Cost/household	1305	1306	1372	416	1157	1196	1173
Variable cost/household	1257	1144	1240	354	1060	1175	1150
Cost (excluding international professionals)/household	676	430	434	318	494	258	348
Cost/ha	225	105	103	42	117	NA	369
Cost/person	121	123	121	42	108	NA	235
Capital (%)	3.67	12.43	9.59	14.94	8.45	1.78	1.94

[a] The table is printed in integer format and may have rounding errors; francs CFA 350 = US$ 1. The discount rate to amortize capital items was 12%/year. Four-wheel-drive vehicles were amortized over 4 years; motorcycles and bicycles were amortized over 2 years; and all vehicles were given a 20% salvage value at the end of amortization. Houses and furniture for field staff were amortized over 5 years, and field equipment (e.g., scales) over 2 years. Office equipment and microcomputers were amortized over 3 years. Some capital costs were tax free (vehicles, especially), others, such as construction materials, included duties. Of the variable costs, the most costly item in the budgets was internationally recruited professional staff — for each one, I assumed $75 000/year. Other variable costs were local professional and support staff salaries, office and field supplies with a service life of at most 1 year, communications, vehicle maintenance, temporary labour, and international travel. All these costs included taxes, except those for gasoline in Upper Volta and Niger.

[b] NA = not available

were assumed to be roughly equivalent to those in Upper Volta and Niger. That assumption could be changed, but it is reasonable if one wishes to compare two methods in the same country.

Capital costs for the extensive surveys were the field vehicle, scientific equipment, and the microcomputer. (Reports of extensive surveys make no mention of the last item, but it is fair to include one given the current cost advantage of micros in Africa.) The costs for these three items were assumed to be the same as they were for intensive surveys (the mean of four surveys). The unit capital costs were multiplied by rates of use — for example, the four-wheel-drive vehicle was assumed to be used for 2 months, a use rate of 0.167.

All operational costs except vehicle maintenance were assumed to be equal to the mean of the intensive surveys. Vehicle maintenance was held at 60% of the intensive mean because enumerators' motorcycles were left out of the extensive surveys. I assumed that office supplies, communications, international travel, and gasoline for the vehicle would not differ between the surveys. In the extensive surveys, I assumed two internationally recruited scientists because farming-systems research teams described in the CIMMYT documents included at least that number.

In terms of costs, the questions are:

- What is the annual cost of each method?
- What is the total cost of each method over the research period?
- Is one cost structure less flexible than the other so that it would lose more if the original research direction were wrong?

- Does one method produce results faster?
- Are there common costs so that advantages of both methods can be exploited?

The mean cost of intensive methods is roughly $1157/household. The range is from $1372 (Niger in 1982) to $416 (Mali). The mean of intensive surveys without the costs of international scientists was $494, ranging from $318 to $676. Expressed in $/member of the survey population, the mean is $117 and the range from $42 to $123.

The estimates for extensive surveys were $1194/household, as estimated from a methodological paper (CIMMYT 1980), and $1169, as estimated from a demonstration of the method in Zambia (CIMMYT 1978). These estimates do not differ significantly from those for intensive surveys. The estimates per hectare and per person in Zambia are much greater than any of the individual estimates for intensive surveys; although this result is clearly a reflection of small family and farm sizes in Zambia, it shows that one cannot always assume extensive surveys are cheaper. Excluding international staff from extensive surveys reduces their costs greatly and makes them less expensive than intensive. The costliest intensive survey was $676, whereas the cheapest extensive was $258. The average intensive ($494) was about 66% more expensive than the average extensive ($297).

For calculations of research expenditures over 5 years at a discount rate of 12%, I took the Niamey 1983 data as typical of an intensive study and those for Zambia to be typical of an extensive one (Table 2). The cost/household is about 24% greater in intensive surveys, although the costs per person and per hectare are greater in the extensive survey done in Zambia. At a 24% discount rate, the relative comparisons do not change, but intensive surveys have a higher cost/household partly because of the capital costs incurred early in the research. Even when only variable costs are considered, intensive surveys are about 15% more expensive than extensive surveys. Flexibility in costs depends on the share of fixed capital and on the care with which research problems are first defined. Extensive methods are

Table 2 Present values of survey costs (US$) at 12% and 24% discounts.*

	12%		24%	
	Niger Intensive	Zambia Extensive	Niger Intensive	Zambia Extensive
Capital	53695	30123	44000	24475
Variable	447071	697704	340487	531369
Total	500766	727827	384487	555844
Households	500	900	500	900
Area (ha)	6638	2862	6638	2862
Population	5660	4500	5660	4500
Cost/household	1002	809	769	618
Variable cost/household	894	775	681	590
Cost — international professionals/household	326	208	254	160
Cost/ha	75	254	58	194
Cost/person	88	162	68	124
Capital (%)	10.72	4.14	11.44	4.40

* Table may have rounding errors. francs CFA 350 = US$ 1.

more flexible than intensive ones because they have lower relative capital costs — but the average share in the intensive surveys is only 8.5% anyway, most of which is spent on enumerators' houses. Other capital — vehicles, computers, furniture — is movable at low cost and is flexible with both methods.

The costs wasted because of poorly designed research, necessitating abandoning a site or a topic, are equal to the annual survey cost multiplied by the time lost. Because annual costs are similar in the two surveys, neither type has a higher expected cost unless one assumes that one type is more likely than the other to begin wrong.

Advocates of the extensive approach argue that their method works faster and with a bigger sample. Collinson (CIMMYT 1980:11) asserts, for example, ". . . the benefits from wide coverage of small farmer populations dramatically outweigh those from a more intensive, numerate approach among fewer populations."

According to my calculations, extensive methods could cover 180–240 households/year. The population covered depends on household size, and the area depends on household size and on farming techniques. In ICRISAT's surveys, intensive methods cover 80–150 households/year. Extensive methods, therefore, work about twice as fast as intensive ones. If each extensive sample is drawn from a different population, then extensive methods permit inferences about larger populations than do intensive surveys.

The speed of extensive methods is an advantage only if three surveys are conducted annually. This is possible but requires quick work and means increased costs if new field assistants have to be recruited at each survey site. It would be particularly difficult in areas of language fragmentation.

The major common costs — international staff, four-wheel-drive vehicles, field staff needed in a more or less fixed proportion to international staff, data processing, and office supplies — and the low share of fixed capital in both methods imply that farming-systems research teams can easily exploit both methods, in particular by joining the immediacy of the extensive method to the analytic power of the intensive one.

Simulating benefits

The relevance of any method is its effect on output. Because no one can accurately quantify how research has affected food production in Africa, it is impossible to put a value on the effects. Still, simulations of how intensive and extensive methods benefit farming-systems research are possible. The simulations sketch answers to questions important for research design: Should research be concentrated in areas with high or low potential? Does the urgency of results affect research methods? Do lags in adoption affect the choice of methods? What sizes of target populations are necessary to repay various research investments?

I have constructed a model that simulates research costs and benefits. It assumes that there is a 5-year project, in which the donor can choose the intensive or the extensive method. Either method increases agricultural growth within 10 years, and the changes in the per-person income that

Table 3. 10-year present values (US$'000s) of benefits (1% increment) from intensive surveys, with and without 6-year benefit lag, at an original income of $150/person and an original growth rate of 1%/year.

	Discount (%)	
	12	24
Income at 1% growth	888	574
With 1% benefits, no lag	930	597
With 1% benefits, 6-year lag	894	577
Cost	501	384
Breakeven target population ('000s)		
No lag	11.72	16.62
6-year lag	82.94	156.66

[a] The values for income are the 10-year present values of per-person income under the conditions assumed for original income level and growth.

exceed the expected annual growth are attributable to farming-systems research. The new level of income is the basis for calculations of the growth the next year. I assumed initial income level to be $150/year, corresponding to rural income in many African countries. The annual expected rate of growth (trend rate) is 1.0%/year. The first increase in growth brought about by farming-systems research is 1.0% — that is, the trend rate is doubled, so that the new rate is 2.0%/year.

I ran the model to see what sizes of target populations were necessary to repay research costs. The sizes of the target populations were tested for sensitivity to the rate of discount; the lag in technology adoption; the original income level; and the trend rate of growth.

Assuming no lag in the entire population's adoption of beneficial techniques, I found that a target population of almost 12 000 is necessary to repay intensive survey costs at a 12% discount rate (Table 3). Another way of looking at the result is that an intensive project providing immediate benefits to 12 000 people has an internal rate of return of 12%. At a 24% rate of discount, a target population of 17 000 is necessary. Extensive research needs a target population of 17 000 at 12% discount and 24 000 at 24% (Table 4).

The benefit–cost calculations for both methods are sensitive to the rate of discount: varying the rate by 100% (from 12% to 24%) causes about a 41% increase in the necessary target population, implying an elasticity of 0.41. The extensive method is no more or less sensitive than is the intensive one. In other words, the urgency of results, used to justify the use of rapid, extensive methods, does not affect the choice of methods.

Advocates of extensive methods argue that their methods produce benefits quicker. If this were so, then such methods would have smaller target populations to repay research costs. I have evaluated this argument by assuming that intensive methods have a lag of 6 years before they produce benefits but that extensive methods have only a 4-year lag.

A 6-year lag in benefits from intensive research at a discount rate of 12% increases sevenfold the target population necessary to repay the costs (Table 3). At a 24% discount, a 6-year lag increases the target population from 16 620 to 156 660. An 8-year lag increases the target population to 612 000. Similarly, in extensive research, time lags increase the target populations

Table 4. 10-year present values (US$'000s) for benefits (1% increment) from extensive surveys, with and without 4-year benefit lag, at an original income of $150/person and an original growth rate of 1%/year.

	Discount (%)	
	12	24
Income at 1% growth*	888	574
With 1% benefits, no lag	930	597
With 1% benefits, 4-year lag	901	580
Cost	728	556
Breakeven target population ('000s)		
No lag	17.03	24.02
4-year lag	52.90	91.03

* The values for income are the 10-year present values of per-person income under the conditions assumed for original income level and growth.

necessary to repay the costs: at 12% and 24% discounts, a 4-year lag more than triples the target populations (Table 4). If extensive methods actually do produce benefits more quickly than do intensive methods, they have a considerable advantage. For example, with a 4-year lag, extensive methods would require target populations only 58–64% of those for intensive methods with a 6-year lag.

Another question I was able to address using the model was whether farming-systems research should concentrate on areas with low or high potential — a question that is widely debated. One school argues for focusing on areas where the potential return is highest — usually in high-rainfall areas. Another school argues for concentrating on areas where help is needed most — among the poorest farmers in the driest areas. If the location does not affect the productivity of research, then one can concentrate on the areas where the help is needed most. To evaluate these arguments, I varied the original level of per-person income and growth rate to model "favourable" (e.g., high-income, high-growth) areas and "unfavourable" (e.g., low income, low growth) areas. If the size of the target populations did not vary when the trend rate of growth or the original income level was changed, then the productivity would not be affected by location.

Table 5. 10-year present values (US$'000s) for benefits (1% increment) from intensive surveys, with and without 6-year benefit lag, at an original income of $300/person and an original growth rate of 3%/year.

	Discount (%)	
	12	24
Income at 3% growth*	1952	1244
With 1% increment, no lag	2049	1295
With 1% increment, 6-year lag	1966	1249
Cost	501	384
Breakeven target population ('000s)		
No lag	5.15	7.41
6-year lag	34.70	65.69

* The values for income are the 10-year present values of per-person income under the conditions assumed for original income level and growth.

I assumed an original income level of $300/year and a trend growth rate of 3.0%/year (Tables 5 and 6) and compared the results with those for the lower income ($150/year) and lower trend growth (1%). I found that increases in income enabled more "profitable" intensive and extensive research because the target populations to repay costs were much smaller. The results also showed that the effects of the lags were much reduced by the higher-income assumptions.

The implication is that research should be concentrated in high-rainfall areas. This conclusion is strengthened if one includes the probability of achieving a given level of growth in the calculations. Because the probability of a 1% increase in the growth rate increases with rainfall, expected benefits (a specified increase multiplied by its probability) are greater in high-rainfall areas. If, as is likely, adoption lags are shorter in high-rainfall areas, including a probabilistic lag also favours placing research in high-rainfall areas.

Survey costs and farmers' participation

Farmers' participation has distinct effects on the costs and benefits at each stage in village-based research: design, execution, and analysis. At the design stage, the farmer provides information about constraints and about investments to relieve them. This role differs little between intensive and extensive methods. Errors occur because farmers, with whom the researchers are not well-acquainted, can make systematically misleading statements. Farmers make errors of magnitude — for example, in exaggerating the prevalence of a disease by reporting only extreme cases. These errors arise from confusion, a desire to please, to hide facts, or to mislead in the hope of receiving aid. They can be reduced by checks and by discussion with informed observers, but there are many examples of unexpected discoveries after long periods in what the researchers thought were well-known areas.

The costs of such errors are increases in the time it takes research to pay off. If one can reduce such errors to roughly zero in 1 year, then at most they would add a year to the payoff period. Because the response of survey benefits to lags is nonlinear — for example, 1 year's lag reduces benefits more if it comes after 7 years than after 3 — then the costs of farmers' errors

Table 6. 10-year present values (US$'000s) for benefits (1% increment) from extensive surveys, with and without 4-year benefit lag, at an original income of $300/person and an original growth rate of 3%/year. [a]

	Discount (%)	
	12	24
Income at 3% growth	1952	1244
With 1% increment, no lag	2049	1295
With 1% increment, 4-year lag	1984	1258
Cost	728	556
Breakeven target population ('000s)		
No lag	7.49	10.71
4-year lag	22.48	38.88

[a] The values for income are the 10-year present values of per-person income under the conditions assumed for original income level and growth.

at the design stage are smaller than at later stages. Because researchers using extensive methods spend comparatively little time with the same farmers, they probably suffer higher costs in terms of farmers' errors than do researchers using intensive methods.

Costs of farmers' participation during the execution stage are generally in the form of unwanted variation in test results. A common error is spreading fertilizer on unfertilized treatments. If this error is known — e.g., if fertilizer is observed in an unfertilized treatment — the researchers can offset it, for example, by using regression analysis, which does not require equal numbers of observations per treatment. This kind of error is damaging in analyses that require equal numbers, such as paired comparisons.

Execution errors, like design errors, prolong the research period and delay the benefits to the target populations. Their distribution depends more on how much input the farmers have (more participation, more error) than on the survey method. I doubt that any village-based research is free of such errors. Although the errors cannot be eliminated, they are likely to be fewer (or at least more likely to be recognized and allowed for in an analysis) in a long-term than in a short-term project because the researchers and farmers have time to identify and eliminate problems in implementation.

Farmers' errors at the analysis stage are similar to those at the design stage. Farmers give biased answers to questions about technologies, probably because they think the researchers want to be told their technology is an improvement. These errors are harmless if there are objective checks on farmers' answers. No one should draw conclusions about yields or about adoption solely from farmers' declarations.

Farmers' errors that introduce random variation into test results increase the sample size necessary to make inferences about a given population. Increased sample size means increased costs and a reduced number of agricultural populations that can be covered with given resources. The bias in farmers' responses at the design and analysis stages increases costs by necessitating expensive objective checks. In the case of crop yields, for example, I have found that farmers understate yields at the design stage and exaggerate them, at least for "improved" packages, at the analysis stage. Uncorrected, these biases increase research costs by making unpromising approaches look better than they are.

Conclusions

My principal conclusions are simple:

- Intensive and extensive methods of research differ little in annual cost/sample unit. Further, they share an approach to farmer-based agricultural research, and they share many cost elements.
- The greatest cost in both methods is for internationally recruited staff. This element far surpasses the costs of local personnel, equipment, or materials and is much more important than assumptions made about discount rates used to value future costs. If this cost can be reduced, then cost comparisons are in favour of extensive methods of research.

- Research should be located in the most favourable areas, if costs and benefits are the criteria: the expected return to research is likely to be greater there and the variance of returns is probably smaller there as well. In West Africa, the distribution of rural income between regions is fairly egalitarian so that regional differences in income distribution should not be too important in the choice of research location.
- The urgency of results from research has little effect on the choice of methods. Although extensive methods have about a 24% advantage in total costs over a 5-year research project, this advantage is not much affected by the rate of discount used to value future costs. Therefore, if the rate of discount reflects donors' impatience for results, one cannot say that even high rates of impatience will make one set of methods better than the other.
- Although lags in benefits from farming-systems research have a large effect on the sizes of the target populations necessary to repay research investments, they do not much affect the choice of research technique. This conclusion, like the previous one, depends on the similarity of costs between extensive and intensive methods.
- Farmers' errors in farming-systems research increase random variation in tests at the execution stage and introduce bias at the design and analysis stages. These errors postpone research benefits and, therefore, increase the target populations necessary to repay research costs. Because the size of the targets is sensitive to benefit lags, reducing farmers' errors is important in controlling costs. There are two ways to reduce errors: use objective methods of analysis to verify farmers' evaluations of technologies, especially about such critical variables as crop yields; and have ample test replicates so that execution errors do not drastically diminish the usefulness of statistical analyses.

Implications

The principal implication is the need to spread the high costs of internationally recruited staff over larger target populations. This is the fastest way of reducing the high cost of research and of extending its benefits. This need is more or less independent of the choice between extensive and intensive methods. It means that much more effort should be made to create standard questionnaires and minimum data sets for extensive surveys (along the lines developed by CIMMYT) to define research zones, whether the extensive surveys are ends in themselves or preliminaries to intensive surveys.

Second, standard questionnaires should be entered into standard data bases accessible to researchers from different zones so that comparisons across zones and years can be easily done. Such comparisons are crucial to an understanding of the fundamental economics of rural areas, without which the research is location specific and anecdotal.

Third, the comparative advantage of research returns in favourable areas argues, analytically, for a concentration of expensive research there and for a concentration of cheap research in the unfavourable areas. Unfortunately, this conclusion is politically unacceptable because fundamen-

tal research is expensive and is needed in the unfavourable areas. One possible approach is for international research investment to be concentrated in unfavourable areas and national efforts in more favourable areas.

Commentary

Souleymane Diallo: The contributions by Vierich and Gladwin et al. indicated the potential role of social sciences, especially anthropology, in developing and refining study tools and methods, as well as understanding farmers' behaviour. These two papers demonstrated the importance of behavioural models and the limitations of rapid surveys.

As the basic objective in farming-systems research is to increase overall farm production, the need for ongoing dialogue between researchers and farmers seems obvious. One-shot surveys are not enough; according to anthropologists, researchers must immerse themselves in the farmers' environment to understand the behaviour and interpret the data accurately.

The examples of misunderstanding between researchers and farmers are multitude. They clearly show that researchers who do not communicate effectively with farmers design technologies that are seldom adopted. Those who consult regularly with farmers are much more likely to succeed.

The papers have promoted reflection on the length of time that should be spent with farmers, the procedure that should be used, and the manner in which questions should be asked to ensure that researchers' proposals meet farmers' expectations and that farmers know what to expect from researchers.

Even the most traditional farming environment has been touched by development policies, projects, and the underlying efforts to transfer new technologies. Past interventions influence the researcher–farmer dialogue; thus, research must take into account the characteristics and behaviour not only of rural societies but also of development policies and projects. As Benoit-Cattin points out, researchers must consider the dialogue between farmers and extension agents and encourage the latter to participate in defining research objectives, conducting surveys, interpreting results, and selecting technical innovations.

Hans P. Binswanger: As researchers, we are interested in involving farmers in research and development because all of us know of many experiences where some crucial farm-level constraint was overlooked and led to the rejection of a supposedly sound technology. The question is: How do we obtain farmer participation that will prevent similar failures in the future?

The paper by Gladwin et al. starts from the premise that the exchange between researchers and farmers is a goal in itself. That is obviously not the case. It is a means for achieving objectives:

- To prevent research and extension failures that stem from the researchers' not knowing constraints faced by farmers;
- To make selective use of farmers' knowledge in suggesting priorities for research; and
- To draw on farmers' knowledge or their solutions and apply these in the research process.

Vierich's presentation uses a number of useful concepts from anthropology to explain why farmer–researcher dialogue is by no means easy. She then illustrates the difficulties without worrying about objectives. She proposes that intensive studies be carried out as the basis for a holistic model of the agroeconomic system within which farmers work and within which they take decisions. An understanding of this decision-making framework is crucial.

Gladwin et al. propose three methods — taxonomies, scripts or plans, and decision trees — as a compromise between diametrically different methods of conducting farmer–researcher dialogues: rapid survey techniques, on the one hand, and long-term surveys within villages (presumably the approach favoured by Vierich), on the other hand. I do not think Vierich would approve of rapid-assessment techniques and not, perhaps, of the Gladwin et al. compromise.

Let me suggest that the debate about intensive versus rapid methods is rather futile. The issue is not one of striking compromises between intensive and rapid approaches — as Gladwin et al. would have one believe. Instead, for each new research or extension team, the issue of method will be one of finding the most effective way of achieving their stated goals or objectives, given the constraints of time, national resources, and intellectual resources. The solutions will differ by type of technology to be developed or transferred.

In addressing the question of how to involve farmers — the topic of both the Vierich and Gladwin et al. papers, we should proceed by asking:

- What kind of knowledge are we seeking to guide research and are farmers likely to know it? Farmers know what their potato-storage problems are and we can go and ask them. However, they cannot help decide whether to breed a high-lysine sorghum variety. One needs to know whether the diets of sorghum eaters are deficient in nutrients and the information can only come from diet surveys.
- How much time do we have? A research unit in a rural-development project may have to produce answers in a few months and must rely on rapid-survey techniques, however imperfect they may be.
- How much money do we have? If a program does not have funds to hire an anthropologist, then other staff, perhaps the agronomist, will have to interview farmers and the method used will vary according to the skills of the staff — an agronomist probably concentrating on farm trials rather than on participant observation of a village community.

T. Eponou: Vierich and Gladwin et al. have presented theoretical approaches and practical considerations involved in raising the level and quality of farmer

participation. These two studies propose improving observations and analyses of the farm environment through the use of ethnological or anthropological tools. Gladwin and her Florida colleagues demonstrate the value of these tools for understanding and resolving specific problems in Florida. The approach seems to be based on practical experience.

Vierich's analysis is not purely abstract either. Her proposal uses the empirical method and personal observation, and her paper gives a number of concrete examples in support. Moreover, she points out the difficulty of establishing objective communication with the farmer. The question is whether researchers actually obtain farmer participation or merely recognize the need to do so. The problem of faulty communication described by Vierich does exist, and anyone with field experience will agree that it continues to plague researchers.

The hierarchical decision-making model advanced by Gladwin et al. may be a relevant analytical tool in Africa, given the risks and uncertainties in agriculture and the complexity of the objectives. It might be used, for example, in the context of work sharing, which plays a small and fluctuating role in African farming because of the exodus from rural areas.

However, I have two reservations regarding such complex analytical methods. First, how useful are such models in the reality of Africa? Second, what impact do they have? These models no doubt enable researchers to collect a great deal of information; however, this information is not always needed. Often, farmers resist innovation because of their rational evaluation of the risks. Owing to broken promises, discontinued projects, and frequent and inconsistent changes in agricultural policy and strategy, they are fully aware of the dangers in adopting new techniques. How much use, then, is information on the farmers' traditional interpretations of their environment?

I would like to remind readers of two facts. The first is that no single approach will work to involve all farmers: researchers will have to pursue many avenues to ensure effective participation by farmers. The second is that economic considerations are not the only factors motivating people; economists claim that all constraints can be explained in terms of operating accounts and budgets. Similarly, anthropologists want to base everything on tradition.

The kind of information one accumulates in long-term observations is expensive and should be balanced with the benefits it makes possible. In other words, one should attempt a cost–benefit analysis of the collections of this type of information, especially in poor countries. Also, researchers should keep in mind that anthropological and ethnological tools, because they are subjective, can be misused and hinder, rather than facilitate, communication.

There are other drawbacks to using these tools: if viewed as complex, they may impede communication among team members or shift interest from shared, multidisciplinary objectives to personal motivations.

R. Billaz: I was pleased to see a unity of purpose at quite a general level in the efforts described. Analysis and testing at the village level in the farmers' physical and social environment are a worthwhile common goal for all the disciplines involved in farming-systems research. However, I suspect that, in

spite of this community of interests, there are important differences at the implementation level.

McIntire's conclusion regarding intensive versus extensive surveys is not convincing. Maybe, his definitions differ from mine. At any rate, the two types of survey are complementary not exclusive. I feel that a given plan must include both extensive surveys using a small number of themes in a large, representative sample and in-depth, repeated surveys conducted in a small number of units. The first type provides information on structures, and the second reveals how these structures work. To oppose the two types of survey seems to me to limit their effectiveness.

In the papers, I find no clear definition of the nature of participation expected or the way that participants are selected, although the composition of the participating group and the degree to which they represent the village community are essential issues. Moreover, I do not believe the authors have dealt adequately with the role of training, which is certainly indispensable in bringing to light the decision-making and selection mechanisms used by farmers. Finally, I wonder about the significance of participation, where the inputs necessary for farmer-conducted testing are provided free of charge. In view of the size of the plots, this constitutes a sizable "gift." Will the same farmers decide to adopt the technology where they have to pay for inputs out of their own pocket?

G. Pocthier: Gladwin et al. and Vierich have several common theses: researchers dealing with farmers must take into account ethnic groups, social classes, political organization, local economic practices, and systems governing access to basic resources; and researchers in different disciplines must learn to communicate with each other. Unfortunately, Gladwin et al. and Vierich have something else in common: they have taken a completely sectoral approach — independent of other basic disciplines such as agronomy, biology, and economics.

I will make three points. The first concerns the composition of the basic team for farming-systems research; the second involves the cooperation of researchers in the farming-systems team with researchers working on broader subjects; and the third concerns communication between the researchers in human sciences and those in biological sciences, who use quite different languages because of their respective approaches and levels of perception.

The main fault with both papers is that they sought more to provide a theoretical framework for the ethnoscientific approach and to refine appropriate methods for the cases analyzed than to promote modification of the development strategy. The activities they recount do not appear to have benefited the farmers.

Reading these papers, it's easy to forget the conditions, especially in West Africa, in which local and foreign researchers carry out their work. Owing to a lack of funds and specialists, farming-systems projects rarely begin with the principal disciplines needed. The majority of the researchers (no matter what their discipline) are fresh out of university and have not had time to acquire relevant experience. Furthermore, they are somewhat isolated from the point of view of methodology and documentation.

Certain features of the West African environment should also be kept in mind. Studies of this environment have been fragmented and difficult to carry out because technical, administrative, research, and other services are scattered. The physical environment, particularly in the Sahel, is changing rapidly owing to the combined effects of population increases and droughts. Consequently, special environmental analyses over widely differing periods are required.

I believe that researchers must intensify their efforts and be creative to overcome methodological weaknesses in certain disciplines, such as agronomy and biology, with respect to tests and evaluations in the real environment at the various levels of perception and to ensure training and scientific monitoring for research teams. In doing this, a balance must be struck between the need for scientific rigour, on the one hand, and the limited means available and time constraints, on the other.

Peter E. Hildebrand: For scientists or technicians to be able to work together in multidisciplinary teams, they first need to be good scientists in their own disciplines. But they also need to know something about the fields of others who are participating on the team, and they must be able to contribute to those other fields. Even more necessary is the openness and security to accept contributions to one's own field from people in other disciplines. The inclination to defend the boundaries of one's own discipline is difficult to overcome. Scientists also need to be able to modify methods that have been developed for strictly disciplinary research. It is simply impossible for members on the team to do everything just as it is done in dissertations. What I am describing is flexibility — in design, in thinking, and in operations. The farmers must be considered as team members. They have to be able to contribute as partners because they know the constraints in their systems better than anyone else. They can contribute throughout the research. Perhaps the most effective means of working in a multidisciplinary team is frequent, frank, and open discussion.

Who is the client for farming-systems research? Some people say other scientists are the clients; others, that national institutions are the clients; and still others, that farmers are the clients. In my opinion, the farming-systems approach makes sense only when it is directed toward the farmer. As farming-systems researchers, we must focus on how to deliver technology to the farmers. If we become concerned about other clients, we muddle our approaches, the types of activities we undertake, the kind of analyses and designs we utilize, and the reports we write. Problems need to be solved now. That is why the farming-systems approach evolved.

Farmers are faced with critical problems. This is too often lost sight of in academic research. In universities, researchers do not feel urgency. They are concerned about models, or about long-term association with "their" village or with "their" crop; they forget the urgency of solving real-world problems. The farming-systems approach is a way of hurrying to get technologies into the hands of farmers to help solve critical problems. Farming-systems researchers cannot take the luxury of ignoring time in their work. In many parts of the world, farmers are moving from a subsistence economy to a survival economy. If we do not help them, there is going to be a real disaster.

I believe that opinions and approaches are converging among those who

have the conviction that the farmer is the client. I think that people who orient their work to communicate with other scientists do things differently. Farming-systems research has its roots in at least three different continents. These roots all developed somewhat independently. They all have their own characteristics. Nevertheless, there is a tremendous amount of convergence in procedures and methods in all projects focusing on the farmer.

The contributions in this volume discuss survey procedures at length. Surveys are just one small part of farming-systems research. Researchers do not have the time nor the luxury to spend years doing surveys before attempting to do something else. They must learn as fast as possible what the conditions are in the areas where they are working and then get on with the task of doing something about the problems. The farmers have been in the areas for years or for decades or for centuries. They are always in a relative state of equilibrium unless something very new, such as an irrigation system, has been introduced. They know what is going on. They have come to grips with it as well as they can and they have a fairly stable farming system. Outsiders bring in an entirely different resource to their system. That resource does not necessarily mean fertilizer or improved seed or irrigation; it is the people who bring it — their knowledge. In partnership with the farmers, they — we — have to set about to see what can be done to improve conditions, given all the factors that are there.

If fertilizer is not available, then researchers should not worry about fertilizer, although they can advise policymakers and infrastructure managers that it should be available. People doing research have got to address the systems that exist and stop finding excuses. They must stop saying they have a perfectly valid technology if only the policymaker would provide a fertilizer market. That does not help the farmers.

Through experience in Guatemala and elsewhere, I have sketched a farming-systems investigation procedure to provide highly focused, problem-solving information on a timely basis.

Farming-system research and extension implies a sequence of participants' inputs, activities, and products in technology development. The main participants are policymakers, infrastructure managers (including research and extension managers), the research and extension technicians (at all levels), and the farmers. Policymakers and managers of infrastructure normally set the preliminary objectives. In most projects, this will include research and extension managers but may also include managers of credit institutions, product and input-marketing institutions, processing plants, irrigation systems, etc. Research and extension technicians, who along with farmers are the main actors, play a minor role at this stage. The time frame for this step is indefinite. It depends on sources of funding as well as competing policy considerations and may take several months or years.

The second step, which should be complete within 1 month, can be called the initial characterization of the area selected. The primary activity is the rapid reconnaissance survey, or *sondeo*. Research and extension technicians and farmers are the primary participants in this activity, with equal emphasis given to the biophysical and the socioeconomic sciences among the technicians. The *sondeo* report is transmitted to relevant policymakers and infrastructure managers, but they do not usually participate in refining project objectives. This activity is carried out primarily by the

managers of relevant infrastructure and by the technicians who were involved in the *sondeo* as well as other technicians.

The third phase is the utilization of the product of the *sondeo* and the refined objectives. Policymakers and infrastructure managers can use this information to determine how specific policies are likely to affect the target farmers and whether the infrastructure can support the policies. The research and extension technicians, working with the farmers, use the information to design solutions — alternatives — to the problems identified by the *sondeo*. Once again, the alternatives are transmitted to the policymakers and infrastructure managers for their information. The technicians, then, are ready to locate collaborators and, along with them, to design trials that will be used to test the alternatives selected for evaluation. The technicians, with the appropriate infrastructure managers, allocate resources to research and extension activities. The time for these activities varies but may be as short as 1–2 months after the refined objectives have been formulated. The activities, as well as those that follow, are heavily oriented toward the biophysical sciences. However, the socioeconomic technicians must participate throughout, as their perspective is vital in evaluation and characterization.

The first three phases are all preliminary to the main activities of the research and extension technicians. The fourth phase is actually an annual cycling of information gathering, evaluation, and redefinition. The main actors are the technicians and the farmers. Following each annual evaluation, results are transmitted to policymakers and infrastructure managers so they will be aware of results and can act upon recommendations when and if necessary. New policies or new infrastructure can influence the kinds of alternatives considered by the technicians and farmers.

R.P. Singh: The approach to farming-systems research described by Lang and Cantrell from field experiences centred on their view of how to use research resources effectively. They felt that intensive collection of labour data, which was undertaken in the first year of their project, demanded too much staff time and resources and the research could not be analyzed quickly enough to be useful. They compromised the next year, using more "one-shot" surveys, avoiding detailed labour-data collection. Their premise that they could not get sufficient time to analyze the data as a means to understanding the major constraints and real farming practices of the farmers suggests that they started their experiments before they were ready. They began on the basis of dialogue with the farmers, which quite often is not based on reality. They have not made it clear how the trials were decided. A more practical approach would have been to initiate on-farm research after they understood the practices of the farmers. By analyzing the information gathered from the farmers, they could have better planned their experiments. Another related issue is that site, climate, etc. may not have been properly understood.

They have not addressed the issue of subsidizing inputs to farmers during experiments, but the practice may lead to high expectations among farmers. Thus, participation by farmers initially may be high but decrease later. Also, the practice may alienate other farmers in the area. I think there are other more appropriate ways to encourage active participation of the

farmers, involving local extension personnel and credit institutions. In farmer-managed trials, the farmers should provide the inputs so that they feel their equal responsibility in the experiments. Researchers can help in obtaining the required inputs at the proper time.

To be able to give any useful assistance, the researchers need to understand how variations in climate and environment affect production and economy of the farmer and how the farmer adjusts to changing conditions. Initiating researcher-managed trials to determine why yields are lower in farmers' fields than on experimental stations is not a valid approach because the agroclimatic environments differ in the two locations. Identifying the effects of individual factors is almost impossible because identifying all the contributing factors is difficult. Researchers cannot control (or even identify) all the contributing factors except by increasing their management input, which is highly sophisticated and not relevant to real conditions. The value in researcher-managed trials is that they bring the researchers into close contact with farm conditions and constraints and allow them to modify their techniques based on their observations. Farmers' participation in diagnosis of farming-systems problems is analogous to the patient participation in diagnosing a health problem. The doctor cannot work effectively without the patient. More important, diagnosing the illness is not an end in itself; the goal depends upon the patient's access to medicines and his or her ability to use them properly.

Probably the most useful contribution by McIntire was to point out the costly nature of internationally recruited scientists. Although he suggests alleviating the burden for such costs by increasing target populations, a more efficient method would be to involve more local, national, and regional staff from universities and institutions. Initially, they could undertake data collection and would become familiar with research techniques. In India, ICRISAT has had some promising results from this approach in collaborative programs with various national universities and organizations. The involvement of these institutions and their scientists provides a useful perspective on the locations quickly and helps in identification of the major areas of research. It also facilitates the on-farm verification trials, avoiding duplication of research. It also avoids unnecessary delays brought about by the need for ICRISAT staff to obtain approval for conducting trials. Finally, it enhances active participation by national program staff, who ultimately bear the responsibility of improving farming systems in India.

Billie R. DeWalt: Today, the debates in farming-systems research are mostly about methods rather than underlying philosophy.

Most practitioners agree that:

- In contrast with previous approaches to agricultural development, we agricultural and social scientists do not know all the answers, and often we do not even know the right questions.
- Farmers usually know most of the right questions and have always been searching for answers.
- Overt collaboration between farmers and researchers can help expand the range of options available and can help us find more answers.

- Farming-systems research is better than other approaches because it puts agricultural development in the correct context, that is, it tailors agricultural adaptation to the existing social, economic, and natural environments.

Because of the disagreements on methods, McIntire has attempted to determine the relative costs of the two main types — extensive and intensive surveys. My own view is that the diversity of methods is much greater than McIntire accepts. And, although his approach is useful, it still does not tell anything about the *quality* of an extensive versus an intensive survey. I suspect that quality depends more on the individuals involved than on the type of method used. Also, attempts to determine the "best" method — applicable everywhere — fly against the trend to put agricultural research and development into a specific context. Different methods are suitable for different contexts, and the context comprises not only the environment of the farmer but also that of the researcher. Different researchers operate in different institutional contexts.

The paper by Lang and Cantrell is a good example of how Purdue University's Farming Systems Unit in Upper Volta has changed over time. All projects, if they are responsive to the information they are collecting, must change and evolve.

Another example is the International Sorghum and Millet program (INTSORMIL), which is a diverse group of researchers assembled from a consortium of eight US universities. Most of the individuals have been working on sorghum and millet research applicable to US settings. Research for international application was often tangential to the main interests of the investigators.

At the time that other anthropologists and I began diagnostic farming-systems research in Sudan and Honduras, we had no idea whether our work would be used directly. As our work progressed, however, INTSORMIL determined that breeding and agronomy work should be begun in both locations. In addition, we forged collaborative links with local and international institutions. The result is that, currently, in both Honduras and Sudan, we have moved into the late stage of technology development and on-farm trials. These programs work because of an effective division of labour among INTSORMIL and the local and international agencies involved. The projects have evolved and function like other farming-systems research projects that operate under the aegis of a single institution.

What is perhaps being illustrated best in the papers and comments in this publication is that farming-systems research strategies are converging, and conferences that bring together practitioners help to promote the convergence. The large number of projects now operating in West Africa promises to provide great opportunities for researchers to compare and contrast their approaches and effectiveness. Such comparisons should lead to suggestions about how to organize future efforts in similar situations.

In conclusion, I believe that, as researchers, we should recognize and learn from the different methods being used for research into farming systems rather than engaging in sanctimonious promotion of our own approaches. Second, I believe that the approaches must be contextualized to make best use of the diverse institutions and individuals involved.

Design and Evaluation

The trend toward greater on-farm activities in many national and international agricultural research programs reflects a growing concern with the lack of success in transferring results from the research station to the farmer. Technologies that show superior on-station performance have much lower yields when introduced into farmers' fields. The reasons for the yield reductions are diverse as are the reasons that farmers do not adopt "improved" technologies. Although the nature and the relative importance of the causes are not yet clear, some technologies developed by agricultural scientists in controlled environments clearly do not coincide with farmers' objectives and do not fit into the physical, social, economic environment.

Hence, many scientists are attempting to extend research to include assessment of new technologies under farmers' socioeconomic and production conditions. Feedback from farmers provides a direct farm-level input into technology design and evaluation and can be used by researchers on experiment stations to bring their objectives in line with farmers' needs. The procedures promise more appropriate production practices to be put at the disposal of extension agencies and the prospect that extension agencies themselves will more actively involve farmers in the adaptation of technologies.

No single approach to on-farm evaluation of technologies is appropriate for all situations. However, one can distinguish a continuum of types of on-farm tests, generally following the movement of a technology from the research station to farmer adoption. Perhaps the most useful criterion for stratifying on-farm tests of technology is the balance between researcher and farmer management. Between the polar cases of entirely researcher-managed trials and entirely farmer-managed trials, there is a range of possible combinations of researcher and farmer involvement in test design and execution. Along the continuum, the farmers increasingly provide the management decisions and inputs, absorbing more of the risks. The variations in management and conditions increase, the analyses grow wider, and the conclusions address the broader production system.

This is the focus of papers within this section. In the opening paper, Peter Matlon sets out a general framework of levels of farmers' involvement in technology evaluation and defines the differing objectives and procedures implied at each level. Within this framework, he examines five case studies based on 4 years of ICRISAT work in Upper Volta and Niger and illustrates the advantages and disadvantages of different types of farmer participation.

The paper by K. Prakah-Asante et al. describes farmer involvement in technology assessment and transfer (TAT) practiced at the West Africa Rice Development Association. The TAT approach is particularly interesting because it calls for information from farmers to be used not only in technology assessment but also in design of extension-education strategies.

Experiences in technology evaluation on farms in northern Nigeria are

presented by G.O.I. Abalu of the Institute for Agricultural Research, Ahmadu Bello University. The paper describes how the program of evaluation has evolved, emphasizes that farmers must be protected from losses caused by research, and contends that on-farm tests should have a strong probability of success.

A novel approach to soliciting farmer feedback — farm-management counseling — is presented by Paul Kleene from work in southern Mali. The feedback from farmers, together with conventional agronomic trials and farmer-managed tests, is described, and factors that can encourage more beneficial farmer input are identified.

In the final paper, Robert Rhoades uses case studies drawn from research on postharvest technology in Peru to demonstrate the considerable capacity of farmers to modify and design their own technologies when they understand the underlying principles. He concludes that researchers do not need to spend scarce resources fine-tuning technologies to local conditions. He emphasizes that researchers must go beyond design of technology and study technology adoption (or rejection) because this is the only valid measure of farmers' needs and resource constraints and of the appropriateness of any technical approach.

Again, the commentary — written by Stoop, Mulugetta, Nygaard, Fussell, and Bigot — has drawn not only on the papers but on the authors' own experiences, which represent widely different parts of the world.

Technology evaluation: five case studies from West Africa

Peter J. Matlon, *International Crops Research Institute for the Semi-Arid Tropics, Ouagadougou, Upper Volta*

On-farm tests of technology are usually distinguished in the literature as either on-farm trials or farmers' tests. In on-farm trials, the researcher manages the trial in an effort to control variation. Examples include multilocational testing of advanced varieties or tests of new and promising intercropping combinations. In farmers' tests, the farmers manage all (or most) test operations. Even management may be a test factor, with the researcher simply monitoring how the test is executed by the farmer.

Between these extremes, the researcher and the farmer are co-managers. How much of the testing should be managed by the researcher and how much by the farmer depends on what is already known about the technology to be tested, what one wishes to examine, what control is required on the levels of treatments, and how precise the data must be.

At ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), I have distinguished between six levels of tests to reflect variation in the inputs, degrees of management and risks absorbed by the farmer, as well as the possible analyses and types of conclusions that can be drawn (Table 1). In levels 1 and 2, all management is provided by the researcher, and land and labour are rented from participating farmers. The value of such trials is to verify agronomic performance of technologies in a wider range of soils and rainfall conditions than are present on the research station and (in the case of level-2 tests) to get early feedback from farmers on the appropriateness of test factors. Level-3 tests, in which researchers introduce and control certain treatments but farmers manage all other operations on the fields and keep the yields, are designed to obtain precise information about response to treatments under farmers' conditions. This approach is appropriate if management (planting date and density, thinning, intensity of first weeding, etc.) is likely to affect treatment response and if it would be difficult to simulate farmers' management. It is preferable to tests that are totally managed by farmers (levels 4, 5, and 6) if exact precision is needed for treatment doses.

In levels 4 and 5, all test inputs are provided to farmers, and recommended practices are explained, but all farm operations, including treatment applications, are done by the farmers. The farmers choose the plots and are free to modify recommended practices within the designated plots. All modifications are recorded so that researchers can identify reasons for change and quantify their effects on performance. The objective of this approach is to duplicate as closely as possible the conditions faced by farmers

Table 1. Levels of farmer participation in on-farm tests of technology.

Level	Description	Farmers' participation						
		Provision of inputs		Management				
		Test factors	Nontest factors	Test factors	Nontest factors	Evaluation	Risk	Scale of observation, analysis
1	On-farm trial	None	Land, labour — fully reimbursed	None	None	None	None	Plot
2	On-farm trial with evaluation by farmer panel	None	Land, labour — fully reimbursed	None	None	Subjective commentary	None	Plot
3	Test of technology exogenously introduced into farming system	None	All — not reimbursed (guarantee possible)	None	All	Objective results, subjective commentary	Limited	Plot
4	Farmers' test	Control-treatment inputs only	All — not reimbursed (guarantee possible)	All	All	Objective results, subjective commentary	Limited	Plot
5	Farmers' test in context of baseline study	Control-treatment inputs only	All — not reimbursed (guarantee possible)	All	All	Objective results, subjective commentary	Limited	Whole-farm
6	Adoption and impact study as follow-up to farmers' tests	All — not reimbursed	All — not reimbursed	All	All	Objective results, subjective commentary	All	Whole-farm

who have just adopted a technology. Baseline surveys of all farming activities are an integral part of level-5 tests so that researchers can examine the effects of the technology at the household level, employing analytical techniques such as complete farm budgeting and optimization modeling.

Level-6 tests closely relate to adoption and impact. All inputs are purchased by farmers, although researchers may find it necessary to make the inputs more readily accessible than under normal conditions of poor transport, inadequate extension, etc. The aim in level-6 tests is to identify in what ways farmers actually incorporate the new technology into their farming systems -- e.g., on what soil types, substituting for what enterprises, what level of management is provided to the technology, and what performance is achieved. Results from this stage provide the most realistic base from which to predict performance, adoption patterns, and consequences. Final conclusions, even regarding the agronomic performance of a new technology, will probably take several years — much longer than at other test levels — because the sample group is likely to be small initially and because it often takes years for farmers to switch from experimental use of new technology to full production.

The ICRISAT West Africa program of on-farm testing

Beginning in 1981, ICRISAT initiated a set of long-term studies in six villages of Upper Volta. The six villages represent three distinct agroclimatic zones, with two representative villages located in each zone. A stratified random sample of farmers was selected, with strata defined by the ownership or nonownership of animal-powered equipment for cultivation. The objective of the sampling procedure was to support comparative analyses of both cultivation systems. Similar studies were initiated in four villages in Niger in 1982. The studies involve an intensive monitoring of the production, marketing, and consumption by about 250 farm units, with 25–30 farmers participating in each village.

Following the first year's baseline study in Upper Volta and during the first year of studies in two of the Niger sites, the on-farm trials (researcher-managed) and farmers' tests (farmer-managed) began. Coordinated by the economics program, these tests involve ICRISAT scientists in agronomy, sorghum improvement, and millet improvement.

The long-term program of on-farm testing provides, first, for a limited number of researcher-managed trials (levels 1 and 2 in Table 1) in study villages believed to represent the zones in which the technology could be adopted. The objective of this phase is primarily to verify regional adaptation and to solicit comments from farmers in each village. If results of the on-farm trials warrant, the technology is advanced to farmer testing (levels 3–6 in Table 1) to confirm performance under farmers' conditions and fit within local production systems.

ICRISAT farmers' tests at levels 3 and 5 last at least 1 year. Level-6 testing begins as early as the second year and involves continual monitoring of how participants incorporate new technologies into their farming systems.

Baseline studies complement the farmers' tests and involve all the participant farmers: they provide data on all production activities — a base

into which test results from single enterprises can be placed for whole-farm analyses. But also, by marginally disturbing local systems with new technical alternatives, one should be better able to understand objectives and constraints in the system and, consequently, the direction and rates of possible change.

An enumerator living in each village is responsible for following 25 farmers. Farmers are interviewed weekly, and the test plots are observed as needed. In addition, a technician living in each zone is responsible for conducting researcher-managed on-farm trials in two villages as well as assisting enumerators in taking agronomic observations on the farmers' tests.

The principal audience for the results of the on-farm tests is other scientists in ICRISAT technical programs. The tests are designed not only to examine technologies that are in a final stage of development but also to examine the concepts and objectives on which the technologies are based. Results are intended to help scientists appreciate the conditions that technologies must satisfy if they are to be widely adopted. Thus, the tests are not a final, preextension screening but an integral part of technology development.

Evaluation criteria

The questions that ICRISAT staff ask and the methods they use to answer them include:

- *What technical performance can be expected under farmers' conditions?* Yield germination, stand establishment, disease and pest prevalence, tillering, and lodging are some of the indicators of performance. For yield, both the means and the modes are identified as measures of central tendency, and the risks associated with adoption are forecast from the variance and frequency distributions of yields, compared across treatments. Particular emphasis is given to the probability of low yields.
- *What factors in the farmers' environment determine yield variability?* Yield-function analysis is the principal tool employed in attempts to identify the sources of variation in yield. Independent variables include both environmental factors (soil type, slope, rainfall, disease and pest prevalence) and management factors (field history, soil preparation, timing of seeding and weeding, manuring, and plant density). This analysis can lead to an identification of the particular conditions in which a new technology has technical superiority, can help specify needed changes in extension advice, and can aid in the identification of technical problems that require further research.
- *Does the technology require farmers to change the level or timing of their resource use, and, if so, do the changes conflict with their capacity or with their other production activities?* Because all farmers participating in the ICRISAT farmers' tests are also included in the baseline studies, the data on inputs and outputs are comprehensive for all farming activities and provide a picture of the entire production system — the context within which resource-use conflicts can be identified and quantified. At a preliminary stage, ICRISAT staff use activity budgets and, later, programing models, to analyze the data.
- *What returns can be expected from the new technology, and how do*

these compare with those from alternative activities? Inputs and outputs are costed so that the returns from each input can be calculated at both the farm level and the societal level. From the baseline data, one can identify constraints that are in effect at specific times on different types of farm units and compare returns accordingly.

- *Is the technology consistent with farmers' consumption goals?* In the case of improved varieties or hybrids, ease of processing, storage, taste, timing of harvest, and quality and quantity of by-products are important.
- *Will the technology be adopted and what are the likely impacts?* In other words, under what conditions (environmental, technical, and economic) will farmers find the new technology profitable, substituting for what other activities, with what level of management, and at what scale?

Case one: cereal–legume intercrop

Information derived from the baseline studies in Upper Volta had shown that cowpea intercropped with sorghum or millet is the most common crop mixture. Densities for the cowpea intercrop tend to be low, generally between 1000 and 8000 plants/ha, although results of on-station experiments in both Upper Volta and Mali have shown optimal densities to be much higher, about 15 000 plants/ha. Researchers also consider increased cowpea to be a means for maintaining soil quality through soil cover, organic-matter production, and nitrogen fixation.

Baseline survey data had also identified sorghum and groundnut mixtures as common in areas of 850 mm or more annual rainfall. These mixtures were characterized by low sorghum densities and relatively high (near-pure stand) groundnut densities.

Against this background, a researcher-managed trial (level 2) was prepared. Its objectives were:

- To measure, in zones of 950- and 750-mm rainfall, the returns to land at low (3000 plants/ha) and high (15 000 plants/ha) densities of cowpea intercropped with sorghum sown at the density found in pure stands;
- To observe how sorghum type, fertilizer treatment, and insecticide use interact and affect intercrop returns;
- To explore the feasibility of increasing sorghum density in sorghum–groundnut mixtures and of introducing the combination in areas where rainfall is less than 800 mm; and
- To solicit farmers' critiques of the trials and their suggestions for alternative means of increasing legume density in cereal-based mixtures.

The trials, designed by ICRISAT agronomy staff and conducted in 1982, were exploratory demonstrations with single replications of each treatment combination. One demonstration was located in each of four villages, representing the 950-mm and 750-mm agroclimatic zones.

Farmers provided land and labour (for which they were reimbursed) and

their comments on all aspects of the trial design. All operations were performed under the direction of a field technician.

Results were lost in both villages in the low-rainfall zone because of problems that plague on-farm experiments. In one village, animals damaged both the cowpeas and the groundnuts so heavily that the legume results were no longer valid. In the other village in the same zone, farmers were busy planting their own fields and were not available to be hired to plant the trial on a timely basis.

In the higher-rainfall zone, the results of the trials indicated that net returns to the land increased by an average of greater than 60% as cowpea density was increased (Table 2). Moreover, the response to density was consistently greater for the local variety than for the improved variety, whereas sorghum yields were higher with the latter. The dense canopy of the improved variety reduced the grain response to increased plant stand. Although the grain yield of cowpeas at high densities increased with an insecticide treatment, the value of the increase was insufficient to cover both the annual costs of the insecticide and the pump. That is, the losses caused by insects were less costly than were the available means of control. Finally, highest returns were obtained for the high-density sorghum–groundnut mixture.

Farmers visited the trials frequently to provide their comments. At the end of the season, all farmers participating in the village studies were assembled for a field day that included an extended walk through, and critique of, the trial. Their comments proved to be extremely valuable in interpreting the objective results of the trial and in deriving implications for subsequent research.

Farmers were generally unimpressed with the increasing aggregate production brought about by increased cowpea density. They pointed out that the risk of animal damage was considerably greater at high densities. They also pointed out that labour requirements for weeding would be substantially greater with a high population of the rampant local varieties of cowpea and that the use of animal traction for weeding and ridging would be impossible. Farmers also observed that the substantial reduction of yields for sorghum (in their view, the priority component in this cereal–legume mixture) was unacceptable. In short, they felt that the possibility of higher financial returns from cowpeas grown at high densities did not offset the disadvantages and that the traditional density better met their objectives and was more consistent with their available labour.

Commenting on the sorghum–groundnut mixture, farmers explained that they considered groundnut the priority crop in the system. They noted that competition for light at high densities of sorghum forced the groundnut plants to grow upward, with reduced rooting and nut formation. They also criticized the spatial arrangement of groundnuts as being too close to allow adequate nut filling. In conclusion, they recommended a planting pattern that would increase the proportion of groundnut in the mixture, give greater room for each groundnut plant, and substantially reduce shading from sorghum.

As a result of the input from farmers, together with the returns analysis, the accent in subsequent on-farm trials of intensified cereal–legume

Table 2. Costs and returns (francs CFA/ha) from an on-farm trial of intensified cereal – legumes intercrops, Koho village, 1982.[a]

	Cowpea density							
	3000 plants/ha		15000 plants/ha					
			No insecticide		Sprayed with insecticide		Groundnut	
	Local variety	Improved variety[b]	Local variety	Improved variety[b]	Local variety	Improved variety[b]	Local variety	Improved variety[b]
Value of production[c]	21921 (32879)	24460 (57622)	37034 (67481)	32393 (44414)	45774 (56625)	34877 (46346)	53822 (60105)	48305 (73786)
Sorghum	8029 (20091)	11396 (49802)	5846 (18537)	8473 (26566)	5846 (18537)	8473 (26566)	4736 (14097)	7400 (27454)
Legume	13892 (12788)	13064 (7820)	31188 (48944)	23920 (17848)	39928 (38088)	26404 (19780)	49086 (46008)	40905 (46332)
Variable cost[d]	542 (11042)	542 (11042)	1057 (11557)	1057 (11557)	1657 (12157)	1657 (12157)	1342 (11842)	1342 (11842)
Sorghum seed	420	420	420	420	420	420	420	420
Legume seed	122	122	637	637	637	637	922	922
Insecticide	—	—	—	—	600	600	—	—
(NPK, 100 kg/ha 14 : 23 : 15)	— (6500)	— (6500)	— (6500)	— (6500)	— (6500)	— (6500)	— (6500)	— (6500)
(Urea, 50 kg/ha)	— (4000)	— (4000)	— (4000)	— (4000)	— (4000)	— (4000)	— (4000)	— (4000)
Capital costs[e]	—	—	—	—	800	800	—	—
Sprayer	—	—	—	—	800	800	—	—
Net margins	**21379 (21837)**	**23918 (46580)**	**35977 (55924)**	**31336 (32857)**	**43317 (43668)**	**32420 (33389)**	**52480 (48263)**	**46963 (61944)**

[a] Figures and items in parentheses indicate where the fertilized trial differed from the unfertilized trial. All other values and inputs were the same.
[b] SRN4841.
[c] Outputs were valued at mean farm-gate prices for a 3-month postharvest period: sorghum, 37 F CFA/kg; cowpea, 92 F CFA/kg; groundnut, 81 F CFA/kg.
[d] Seed was valued at mean farm-gate prices for May – July 1982: sorghum, 40 F CFA/kg; cowpea, 120 F CFA/kg; groundnut, 75 F CFA/kg. NPK fertilizer was valued at 65 F CFA/kg and urea at 80 F CFA/kg.
[e] Depreciation for spraying equipment: 5-year pump life, 3 ha/pump.

mixtures has been shifted to groundnut-based systems. Planting patterns were modified to reflect the objectives expressed by the farmers, and early maturing varieties of sorghum and millet were sown late in some treatments (an alternative not now available to farmers) in an attempt to increase sorghum densities without adverse effects on the groundnut.

Case two: measuring fertilizer response

Farmers' tests conducted in Upper Volta in 1982 had measured the profitability and risks associated with the recommended dose of NPK (14 : 23 : 15) cotton complex fertilizer when used with both local and improved cereal varieties. The analysis did not answer the question of whether the recommended dose was optimal by financial and economic criteria and whether the risks were the same at levels other than the recommended dose. To answer these questions required data from tests that would allow a comparison of yield responses at different fertilizer levels and the calculation of profit distributions. Moreover, the profitability of urea in combination with cotton complex fertilizer had not yet been tested in Upper Volta under farmers' conditions.

A joint researcher- and farmer-managed trial (level 3) was set up with the objectives to:

- Estimate response functions to cotton complex fertilizer in each of the three agroclimatic zones, and, based on these results, calculate levels that maximize financial and economic profitability in the short term;
- Calculate the probability distribution of gains and losses associated with a range of fertilizer doses applied to local and improved varieties in different regions;
- Measure the profitability of applying urea at a recommended dose and the probability of losses and gains, again by variety and region; and
- Identify and measure the effects of management factors (e.g., soil preparation, fertilizer use) and microenvironmental factors (e.g., soil type) on returns.

The trial was designed to combine researcher and farmer management because the amounts of fertilizer applied had to be precise, whereas, in previous farmers' tests, farmers had modified recommended fertilizer doses in up to 30% of all cases.

A level-3 fertilizer-response trial combined with a level-5 varietal test seemed to be the most workable. Field assistants would intervene to apply fertilizer on plots demarcated within farmers' tests of improved and local cereal varieties, and all other operations were to be performed by the farmers.

Six fertilizer doses were selected. Included was the recommended dose (100 kg/ha) of cotton complex fertilizer with and without urea. The number of treatments/farmer was limited to four so that errors in reporting would not be unacceptably large. All farmers received three treatments (0; 100 kg NPK/ha; 100 kg NPK/ha plus 50 kg urea), and the remaining three treatments were randomly distributed, with each farmer receiving one (50 kg NPK/ha; 200 kg NPK/ha; or 400 kg NPK/ha). Detailed data on operations

ICRISAT technician records labour data for the framework within which the effects of new technologies can be measured.

were collected for each of the eight test plots. Yields were measured by field enumerators, harvesting each plot completely. Because the trial is being carried out in 1983, results are not yet available.

Case three: varietal tests

Between 1980 and 1983, the ICRISAT economics program in Upper Volta and Niger tested 14 of the most promising sorghum and millet varieties from each country's crop-improvement programs. The approaches used in the tests (level 5) have evolved and illustrate how a fairly uniform design can, with only minor modifications, address a relatively wide range of issues in technology evaluation.

The major objectives have been:

- To assess new varieties for agronomic performance, fit into local systems, and consumer acceptability;
- To evaluate the economics of agronomic practices and inputs in combination with local and improved varieties; and
- To measure yield losses caused by pests and diseases.

These various objectives can be satisfactorily met with a split-block design, which permits the researcher to examine both the main effects and interactions of varietal and agronomic treatments. Each farmer cultivates a single replication of the four-treatment block, with sites serving as replications for subsequent analysis. Plots employed in farmers' tests should be large enough to provide insight into performance under nontest conditions but not so large as to impose an unreasonable burden or risk on the farmer. In 1981 and 1982, for varietal tests on treatment plots of 250 m^2 farmers used levels of labour and nonlabour input that did not significantly differ from their traditional fields. Smaller plots (100 and 150 m^2) are being tried in 1983 as a test of whether an increased number of treatments can be satisfactorily

introduced on about the same total area. For farmers' tests of agronomic practices where labour inputs are changed or economies of scale are expected, 250 m^2 is a minimum. Larger, and perhaps various-sized, plots stratified across sites might be necessary.

Sites are selected by each farmer on soils suitable for the crop being tested. To facilitate farmer recall and staff observations, colour-coded stakes indicate treatment locations, and plot placement is not randomized. Data on labour use and nonlabour inputs are obtained in weekly interviews. Cropping histories for each plot are also obtained. The microenvironment (soil type, slope, etc.) is observed during staking, and the findings are recorded. Agronomic observations (seedling establishment, insect and disease damage, lodging, etc.) are noted at appropriate times in the season. The densities of plants and heads as well as yield are determined at the end of the season by field staff who harvest the entire crop.

Agronomic treatments represented farmers' current practices for the crop being tested (zero tillage, no fertilizer) and the package recommended by the extension service (preplanting plowing and 100 kg NPK, 14 : 23 : 15/ha).

Farmers generally have had little problem in following the recommended treatments for varietal tests in a systematic split-block design with colour-coded inputs and stakes for the plots. However, because the farmers perform all operations and are free to modify the recommended practices, field staff must visit the plots regularly with the farmer to verify the treatments. These visits are particularly crucial during operations early in the season when fields are planted, manure and fertilizers applied, etc. so that information elicited in interviews can be verified and, when necessary, corrected.

A sample of results drawn from several varietal tests demonstrates the types of analyses and conclusions that can be supported by such farmers' tests of varieties.

Agronomic performance and fit

Major criteria employed in evaluating the agronomic performance of new varieties are seedling establishment, mean yields, yield variability, and yield determinants. Tests of the improved white sorghum variety E 35-1 in 1980 and 1981 and the red sorghum Framida in 1982 provide useful examples of the first three criteria.

Results of farmers' tests in 1980 showed that, with low tillage, seedling emergence was significantly ($P<0.05$) lower for E 35-1 than for local varieties and consequently that soil preparation by animal traction was essential for a full stand of E 35-1. However, the baseline survey had shown that plowing requires nearly 200 person-hours/ha by hand hoe and 60 person-hours by donkey traction. This labour requirement and the need to delay plowing until immediately after a rain would bring E 35-1 into conflict with the timely planting of local varieties.

Confirmation of these results for E 35-1 and for other elite sorghum varieties in subsequent farmers' tests led to the initiation of systematic laboratory screening of promising sorghum varieties for emergence. As for E 35-1, a crossing program was begun to incorporate improved emergence and seedling vigour.

Table 3. Mean yields (kg/ha) of improved and local sorghums by position along the toposequence at two levels of management, level-5 farmers' tests, Nakomtenga and Nabitenga, 1981.

	Low management				High management			
	E 35-1	38-3	CSH5	Local	E 35-1	38-3	CSH5	Local
Plateau								
Mean yield (kg/ha)	—	318	144	189	—	185	813	273
Observations	0	1	1	1	0	1	1	1
Upper slope								
Mean yield (kg/ha)	268	305	773	605	966	1048	1256	1102
Standard deviation	286	395	377	473	668	693	480	553
Observations	8	7	9	12	8	7	9	12
Mid slope								
Mean yield (kg/ha)	685	311	537	626	1405	915	1369	1197
Standard deviation	609	376	374	459	763	362	583	454
Observations	17	16	15	24	17	16	15	24
Lower slope								
Mean yield (kg/ha)	810	516	602	606	1389	1106	1202	1150
Standard deviation	645	655	313	525	1162	799	1033	588
Observations	4	6	4	7	4	6	4	7

Because variability between sites is typically wide, a comparison of mean yields from all sites rarely gives significant results. Alternative approaches that can be used in the absence of computer equipment include t-tests of mean differences with paired observations for each site and the poststratification of sites according to principal site and management characteristics. The advantage of poststratification is that one can examine differences in response to the stratifying factors and thus identify the conditions under which particular varieties are best adapted.

Poststratification analysis (Table 3) of mean yields for two improved sorghum varieties, one hybrid, and a local variety suggested that local varieties and, to a lesser degree, the hybrid CSH 5, were more widely adaptable than E 35-1 but that E 35-1 was best adapted to fields on the lower half of the slope under low-input management and to both mid- and lower slope fields under high management.

Combining poststratification analysis with data on labour use and factor returns (for the test varieties and for all other farm-level activities included in the baseline survey) can elucidate probable adoption patterns and fit within existing systems. For example, in 1980, an analysis of yields across field locations showed that E 35-1 achieved significantly ($P<0.05$) greater yields only on fields where it received large amounts of organic refuse — that is, fields adjacent to family dwellings. As baseline data showed that these plots are predominantly sown with maize and red sorghum, budgets were calculated, and the returns to both land and labour for E 35-1 were compared with those for the alternative crops sown near the compound. The analysis revealed that, on highly manured soils, E 35-1 was significantly more profitable than local sorghums but not more profitable than maize. Moreover, because maize is harvested 1 month earlier than E 35-1, it serves a critical role in providing calories before the major cereal harvests. This source of food during the hunger period would be foregone if E 35-1 were substituted for maize. Also, technical budgets showed that soil preparation and planting of the shorter-cycle and later-planted E 35-1 conflicted with the

Table 4. Financial budgets (CFA/ha) for E 35-1 and local sorghum under seven management classes[a], level-5 farmers' tests, Nakomtenga and Nabitenga, 1981.[b]

	Zero tillage		Traction line tracing		Traction plowing		Hand plowing, chemical fertilizer		Traction plowing, chemical fertilizer		Hand plowing, chemical fertilizer, manure		Traction plowing, chemical fertilizer, manure	
	E 35-1	Local	E 35-1	Local	E 35-1	Local	E 35-1	Local	E 35-1	Local	E 35-1	Local	E 35-1	Local
Value of output	44806	39265	28441	29680	70168	57990	52873	71128	58061	69472	143115	81401	96310	98533
Variable costs	1546	1431	1337	1266	1337	1273	5793	5147	5327	5068	20111	18406	18960	18745
Gross margins	43260	37834	27105	28414	68791	56717	47081	65981	52734	64404	123004	62994	77350	68788
Animals and equipment	1068	950	2152	2052	2437	2671	515	515	3220	3329	515	795	3247	3400
Net margin to household, labour, management[b]	42192 (43420)	36884 (30262)	24952 (26659)	26362 (18348)	66354 (52270)	54046 (39684)	46566 (29054)	65446 (33271)	49514 (39178)	61076 (32682)	122489 (67692)	62200 (41021)	74103 (54981)	65388 (38780)
Total labour (CFA/h)	106 (125)	95 (77)	75 (80)	79 (77)	148 (105)	141 (882)	58 (18)	155 (106)	131 (109)	155 (98)	150 (21)	80 (48)	131 (106)	144 (159)
Production labour (CFA/h)[d]	149 (125)	121 (95)	116 (139)	115 (121)	241 (189)	227 (140)	64 (21)	213 (156)	173 (137)	207 (139)	178 (43)	95 (60)	183 (181)	203 (254)
Marginal rate of return to total costs over lowest-cost management class	—	—	-1970%	-1124%	2015%	1098%	118%	871%	123%	402%	445%	151%	163%	144%
Observations	11	15	10	16	5	7	3	9	9	13	4	8	14	17

[a] Management classes appear in ascending order by cost, with zero tillage being least expensive and traction plowing, chemical fertilizer, and manure being most expensive.

[b] In parentheses is standard deviation.

[c] Outputs and variable costs were valued at mean farm-gate prices.

[d] Total labour time, unweighted for age or sex, less labour used in harvest.

first weeding of local sorghums. The conflict would be eliminated if E 35-1 were substituted for local varieties. Thus, the improved variety would probably be adopted primarily on the most fertile soils, but as a replacement for local sorghums rather than maize. Subsequent analysis of adoption patterns has supported the early projection.

Depending on the distribution of yields, over time and across sites, the mean may be an inadequate tool to evaluate yields and to project adoption patterns. Examination of yield distributions can provide valuable additional information on stability across soils and management conditions and on risks associated with adoption. In both 1981 and 1982, for example, the distribution of yields from farmers' tests of local varieties were more peaked and concentrated around the mean, whereas those for improved varieties, which were responsive to management, were substantially more positively skewed. With a positively skewed distribution, adoption patterns projected from the mean alone would likely be unrealistic because the probability of yields below the mean exceeds that for yields greater than the means.

Agronomic practices

The early designs of ICRISAT farmers' tests of varieties provided for two discrete management levels, representing local and recommended practices. Because of modifications introduced by farmers (e.g., use or nonuse of manure, tillage equipment, etc.), however, the number of management "packages" were often substantially more. Given a sufficient number of observations, one can analyze these management packages to determine incremental changes in returns with the evolution to more complex and costly systems.

One such budget analysis (Table 4) showed no consistent or significant differences between E 35-1 and the local variety in returns to either land or labour and no trend in differences as one moved from low- to high-cost management. Although the low number of observations and the high variation in data make conclusions somewhat suspect, the local variety appears to be at least as responsive as E 35-1. For example, in several management classes, the local variety responded relatively more to chemical fertilizer than did E 35-1. Also, the rate of return to incremental costs over the base management class (zero tillage and no fertilizer) tended to fall with the adoption of higher cost systems. Nevertheless, the marginal return to total costs in the fully developed system (traction plowing, chemical fertilizer, and manure) remained attractive for both varieties at between 140% and 180%.

Another example of how data from tests of improved varieties can be used to evaluate the economics of agronomic treatments is drawn from farmers' tests conducted in 1982 when rainfall was below average. Data were analyzed to determine the average financial and economic returns to the recommended dose of NPK fertilizer as well as the risk of financial loss by zone, variety, and price conditions. The results (Table 5) showed that, for local sorghum varieties, average financial returns to fertilizer were highest (80%) when applied in the high-rainfall zone, declined systematically (40%) in the intermediate-rainfall zone, and were negative when applied to the dominant cereal, millet, in the lowest-rainfall belt. Returns for improved varieties were consistently higher than those for local varieties and were positive.

Table 5. Returns to 100 kg NPK (14 : 23 : 15) fertilizer/ha with and without subsidy by variety and region, level-5 farmers' tests, 1982.

	Average return to cost of fertilizer over 6 months (%)[a]		Plots where return was less than break even (%)			Minimum cereal yield increments necessary to break even (kg/ha)			Grain prices[c] (CFA/kg)	Number of paired observations
	With subsidy	Without subsidy	With subsidy	Without subsidy	FAO 2:1[b] criterion	With subsidy	Without subsidy	FAO 2:1 criterion[b]		
Djibo										
Souna 3	19	−39	56	72	72	94	184	188	69	18
Local millet	−16	−57	61	72	72					18
SPV35	190	49	46	62	62	100	195	200	65	16
Local sorghum	71	−12	62	77	77					16
Yako										
SRN4841	44	−26	54	69	69	163	318	325	40	13
Local sorghum	42	−27	69	69	69					13
Boromo										
SRN4841	153	30	28	44	44	176	343	352	37	18
Local sorghum	77	−9	44	61	61					18

[a] Not annualized.
[b] Increment needed to produce a benefit : cost ratio greater than 2 at financial prices with subsidy included.
[c] Cereal prices are the average, for 3 months postharvest in each region; fertilizer prices are 65 CFA/kg with subsidy and 127 CFA/kg without subsidy.

The results also clearly demonstrated the high risks associated with fertilizer use in semi-arid conditions under farmers' management. Thus, even with mean financial returns of 77% and 42% in the high- and middle-rainfall zones, the percentages of fields where incremental yields did not cover subsidized fertilizer costs were 44 and 70 for the local varieties. Costing fertilizer at its unsubsidized price found average negative returns for all cases except improved sorghum varieties in the high-rainfall zone and under lowland conditions in the lowest-rainfall zone. An important question left unanswered was whether the recommended dose (100 kg/ha) of the available NPK fertilizer was the optimal dose. A farmers' test was subsequently designed to address this question.

Although tabular analyses of yields stratified by management and environmental factors can point toward likely causes of yield variation, yield-function analysis by computer can be a more powerful tool to measure the independent effects of a range of yield determinants. For example, regression analysis of an improved red sorghum variety, Framida, tested by farmers in two agroclimatic zones provided useful information concerning varietal response, fit, and the economics of various management factors (Table 6).

Table 6. Regression coefficients for yield determinants and varietal effects of the improved sorghum variety Framida, level-5 farmers' tests, 1982.[a]

	SRN4841			
	Yako/Ziniare		Boromo	
Improved variety ×				
Alone	1.31	(0.01)	181	(1.05)
Plowing	235	(1.21)	349	(1.35)
Fertilizer	1.64	(0.93)	0.19	(0.09)
Plateau soils	−63	(−0.18)	−270	(−1.12)
Lower slope soils	−110	(−0.43)	107	(0.32)
Lowland soils	−141	(−0.47)		
Management factors				
Plowing — local variety	−155	(0.79)	−186	(−1.01)
Chemical fertilizer — local variety	1.61	(1.25)	2.93	(2.02)
Plowing × fertilizer interaction — local variety	−0.31	(0.16)	−0.03	(−0.21)
Manure	0.04	(2.36)	—	—
Date of planting	5	(1.06)	121	(0.95)
Date of planting squared	−0.02	(−1.50)	−0.16	(−1.06)
Field location				
Village dummy 1	−90	(−0.66)	−76	(−0.61)
Village dummy 2	−151	(−1.30)		
Plateau soils	−132	(−0.46)	130	(0.73)
Lower slope soils	−79	(−0.42)	491	(2.01)
Lowland soils	91	(0.43)		
Field history				
Sorghum preceding crop	−64	(−0.66)	−169	(−1.08)
Legume preceding crop			−105	(−0.33)
Fertilizer applied preceding year	17	(0.24)	121	(0.76)
Constant	1039		−21587	
R^2	0.33		0.37	
F	2.98		3.21	
Degrees of freedom	117		88	

[a] t-statistics are included in parentheses.

In brief, the analysis suggested that, under conditions of low management, Framida yields were essentially identical to those for local varieties in the low-rainfall zone but probably superior in the high-rainfall zone. Yield response to plowing for the improved variety was significantly greater than the locals. The results also showed that the improved variety was less well-adapted to shallow plateau soils than were local varieties but probably superior on mid-slope fields (the reference soil type) on the toposequence. Combining the technical coefficients on fertilizer response with input and price data, the analysis also suggested that, at recommended doses, the NPK fertilizer was financially profitable when applied to local varieties only in the high-rainfall zone. In contrast, application of fertilizer was profitable for the improved variety in both zones.

Pests and diseases

Although an accurate assessment of the potential gains to investment in research on crop protection requires detailed estimates of the yields that would be lost without protective measures, such estimates are rarely available under farmers' conditions. With adequate resources for numerous observations on disease and pest prevalence, farmers' test plots provide an extremely useful medium for such an assessment.

Methods to evaluate the economic cost of factors causing yield losses have been developed in the context of farmers' tests conducted in the ICRISAT Niger program. The procedure used has been to score at appropriate times for the presence of bird damage, *Raghuva*, downy mildew, wild millets *(Chibra)*, *Striga*, and stem borers. The scores are then included as independent variables in regression equations of yield functions. To arrive at the value of foregone output, one multiplies the estimated regression coefficients by the mean values for each factor responsible for losses and in turn by the postharvest price of millet (CFA/kg).

The results of such an analysis for the farmers' tests conducted in 1982 showed clearly that bird damage, *Striga*, and downy mildew were of no economic importance (Table 7). Stem borer had one large and significant ($P < 0.05$) loss value for the local variety but was otherwise insignificant. The outstanding causes of yield loss were *Raghuva* and *Chibra* millets. In all except one case, they resulted in statistically significant yield losses of more than 4900 CFA/ha, representing between 11% and 25% of the gross value of output. Combined, the two reduced output 27–37%.

Farmers' assessments

Farmers were initially overly positive when asked to evaluate production and consumption qualities of materials introduced by researchers. For example, in the 1980 tests of E 35-1, when farmers were asked to compare yields of the new variety with their local, only 70% responded correctly; that is, their responses agreed with the results of the yield-plot results. Moreover, of the farmers who responded incorrectly, 70% erred in favour of the introduced variety. In 1982 tests carried out with a separate sample of farmers, only 54% of farmers answered correctly. And, of those who answered incorrectly, 66% erred in favour of the test variety. Both ratios are significant at the 5% level. Similarly, when one of the varieties tested that year suffered widespread lodging, farmers in a group session were extremely reluctant to admit the deficiency.

Table 7. Values (CFA/ha) of yield-reducing variables, farmers' tests, 1982.

	Equation number[c]		
	1	2	3
Birds			
Value[a]	—	704	—
% of revenue[b]	—	1.7	—
Raghuva			
Value	4419*	8453**	5712**
% of revenue	11.9	19.9	14.3
Downy mildew			
Value	2098*	—	768
% of revenue	5.7	—	1.9
***Chibra* millets**			
Value	9260**	6391**	5214**
% of revenue	25.0	15.0	13.1
Striga			
Value	—	715	423
% of revenue	—	1.7	1.1
Stemborers			
Value	16002**	—	3493
% of revenue	43.1	—	8.8
Mean millet yield for equation	301.6	346.3	324.0

[a] Values are the regression coefficients multiplied by the mean value of the variable times the market price of millet, 123 CFA/kg.
[b] Revenue is the mean yield of millet for the equation times the millet price of 123 CFA/kg.
[c] Significance values: * = 0.10; ** = 0.05.

These experiences advise one to be cautious in giving a great deal of weight to farmers' assessments until they fully understand the experimental nature of the tests and until they feel at ease in criticizing technologies brought to them by the researcher. One is also well advised to combine subjective assessments with objective tests of the same elements whenever possible to identify the presence and direction of such biases.

Case four: farmers' tests of sorghum–cowpea intercrop

As a complement to on-farm trials of intensified cereal–legume intercropping systems conducted in 1982, farmers' tests of sorghum–cowpea systems were simultaneously conducted in identical village locations.

The tests (level 5) were carried out with two objectives:

- To measure the increased labour demands for planting and cultivating cowpea intercropped at high densities with sorghum; and
- To determine how returns to labour varied with changes in cowpea density.

A split-block design was used with two levels of cowpea density (3000 and 15 000 plants/ha) and two levels of fertilizer (0 and 100 kg 14 : 23 : 15 plus 50 kg urea/ha) as the test treatments. Each of the four possible treatment combinations occupied an area of 250 m² demarcated by colour-coded stakes. Sorghum density was to be constant at 60 000 plants/ha, and only local varieties of both sorghum and cowpea were sown.

Data were collected from farmers in weekly interviews and verified

through frequent observations. Sorghum yields were measured through two systematically placed 10 m^2 plots in each treatment, and for cowpea through the complete harvest of each 250-m^2 plot.

In marked contrast to experiences with varietal tests, farmers generally did not respect recommendations concerning the major test factor, cowpea density. Densities varied widely, often irrespective of plot designation. And in a portion of cases, the sorghum and cowpea seeds were sown together in the same hill, as per local practice. Reasons for these departures from recommendations were not satisfactorily determined, although many farmers had difficulty understanding and remembering the guidelines. Moreover, many farmers did not appear to view changes in cowpea density as a discrete "new technology" needing to be tested and saw no point in planting cowpea and sorghum in separate hills — a practice that requires additional labour.

Not anticipating such a wide variability in cowpea densities nor a substantial loss in cowpea plants during the season (as conventionally occurs on farmers' fields), field staff observed the plant stands only once at the time of harvest. This error in design led to later analytical problems relating cowpea density to net aggregate returns.

Because of farmers' modifications in execution, the test results could not be analyzed on the basis of two discrete density levels. Rather, the variation in density required a poststratification of plots into three ranges of cowpea density (2000–4999; 5000–10 999; and 11 000 plants/ha) for labour-use analyses.

The labour data confirmed farmers' comments during the critique of the on-farm trials. The change from planting sorghum–cowpea together to seeding them on separate hills increased planting labour by at least 20%. As the cowpea density increased to between 5000 and 10 999 plants/ha, labour time for cowpea planting alone increased by an additional 50% over all sites. The additional care required to weed high-density cowpea also resulted in an increase (25–50%) in total labour use for first and second weedings in the different village sites. Finally, the data showed that the frequency of ridging also declined directly with higher cowpea densities, suggesting any advantages from ridging would be foregone in a high proportion of fields if high-density cowpea systems were to be introduced.

When data were pooled across sites, labour for the peak period of planting and of weeding increased by more than 40% overall for a shift from sole sorghum to an intercrop with cowpea at a moderately high density (5000–10 999 plants/ha). At an opportunity cost of roughly 35 CFA/h during June–July, this represents an additional labour cost of nearly 5000 CFA/ha.

Thanks to the wide variability in cowpea densities introduced by farmers, the independent functional relationship between cowpea density and factor returns could be estimated by regression analysis. A profit function was fit with factor returns as the dependent variable and a range of profit determinants (including cowpea density and cowpea density squared) as independent variables.

The partial relationship linking returns to labour and cowpea plant stand (Fig. 1) indicated important differences between agroclimatic zones with

respect to the optimal cowpea density. Interestingly enough, the optimal ranges were relatively stable with or without fertilizer.

The principal conclusion drawn from this farmers' test is that, under farmers' conditions, optimal densities of spreading local cowpea varieties intercropped with sorghum are probably substantially lower than suggested from trials on the experimental station and not greatly different from farmers' current practices. A promising direction for additional research, suggested by the farmers' test results, is the possibility of higher density cowpea intercropped with sorghum using upright cowpea varieties sown in the same pocket with sorghum. This approach would eliminate the additional labour demands for planting and weeding that were present in the system tested.

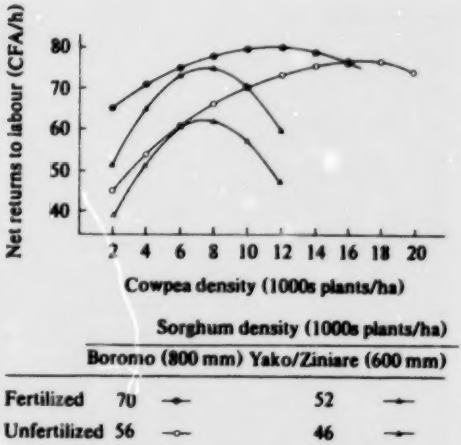


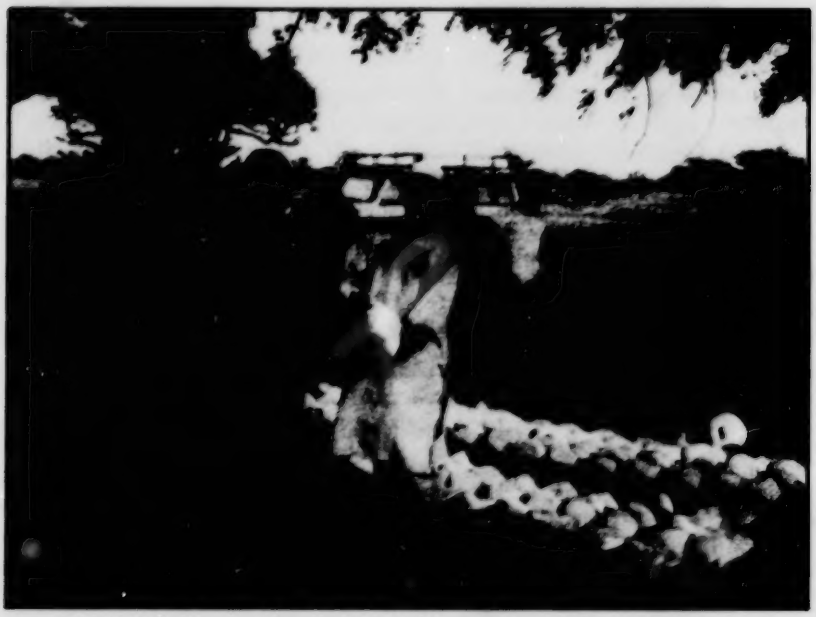
Fig. 1. Changes in cowpea density in farmers' tests clearly affected the returns to labour in a sorghum–cowpea mixture in two rainfall zones, 1982.

Case five: follow-up — patterns and consequences of adopting a new variety

Because all ICRISAT sample farmers participate simultaneously in tests of technology and baseline studies, farmers are automatically followed up in an effort to determine to what extent they adopt elements of the test technologies. Because of possible biases in level-5 tests, this subsequent stage in the farmers' tests is believed to give the most accurate information on adoption potential and impact. As such, results drawn from follow-up studies (level 6) serve to verify provisional projections made on the basis of level-5 test results. Follow-up of farmers who had participated in 1980 tests of sorghum E 35-1 as a possible substitute for local varieties or for maize is a good example.

Activities on all cereal fields cultivated in 1981 by 44 participating households were followed through weekly interviews. Farmers were asked to estimate, from recall, yields and applications of inputs such as seed and manure. They used local units for quantities and these were converted to metric weights, later, from samples. All fields were measured by compass and chain.

The major problem in implementation derived from the high yield variance caused by differences in environmental and management factors. Lack of computer facilities in 1981 meant that some types of analyses were not performed. In particular, the independent effect of variety on yields and returns could not be determined by means of regression models.



Distributing seed for sorghum trials under farmers' conditions.

The results nevertheless indicated that the adoption and management of E 35-1 corresponded remarkably closely to projections from level-5 tests. As had been predicted, early adoption was more common among farmers who had animal traction and, thus, added capacity to prepare the soil and added access to manure.

All nonadopters had experienced significantly lower yields than adopters for both E 35-1 and the local sorghum check during the previous year's tests. This finding reflected a greater propensity for early adoption among efficient farmers. Moreover, the difference of E 35-1 yields in 1980 less yields of the local check was positively (but weakly) correlated ($r = 0.26$) with the area of E 35-1 sown in 1981. Although farmers were clearly influenced by the relative performance of each variety, other factors were more important so that plantings continued to follow an exploratory, experimental mode.

The farmers' evaluations of E 35-1 after the 1980 harvests were poor predictors of early adoption. Although the percentage of low scores given to E 35-1 on a wide range of performance and consumption criteria was generally higher among nonadopters than adopters, in no case was the difference significant. This result has been confirmed in subsequent seasons in other locations: namely, that farmer evaluations obtained in interviews tend to be positively biased toward the test materials, and, as such, result in poor projections of subsequent behaviour.

Nevertheless, the 1981 data on cropping patterns and field management showed that farmers had correctly assessed the management requirements of E 35-1. Thus, they tended to concentrate fields for E 35-1 close to their dwellings for ease in management and manuring. As a result, the E 35-1

Cowpea experiments in Upper Volta.

fields received 4 times the amount of manure and 10 times the amount of plowing labour devoted to the average local white sorghum field. Also reflecting farmers' recognition of the responsiveness of E 35-1 to fertilizer, E 35-1 was sown more often on plots previously in fallow or sown to legumes than was the local.

In level-6 tests, where farmers provide all inputs and modify recommended practices to fit their resources, multivariate analysis is essential to reduce unexplained variance in nontest factors (such as soil quality, timing and intensity of operations, etc.) and to isolate the independent effects of response parameters. Although regression techniques are the most powerful tools for this purpose, lacking computer capacity, one can learn much from budget analyses that poststratify cases by environmental or management variables.

For example, poststratification of results in the 1981 follow-up studies provided a good means to evaluate the financial performance of E 35-1 compared with local varieties. The 63 sorghum fields cultivated by participant farmers were poststratified according to method of soil preparation, fertilizer application (with or without), and variety. Further poststratification according to level of fertilizer applied or field type was not possible because of insufficient observations.

Poststratified test data support several other types of analyses that provide useful insights into possible patterns and consequences of adoption. For example, further analysis of the poststratified data from the 1981 follow-up showed that the highest-cost management package together with the local variety should be the preferred treatment and that the adoption of

higher cost management was generally associated with increasing returns to both land and labour. Thus light animal traction plus fertilizer may be appropriate for both land- and labour-scarce households. Moreover, for E 35-1, the rate of increase in returns to labour was in fact somewhat greater than for returns to land, suggesting that the technical packages compared were probably somewhat labour, rather than land, biased.

Concluding observations

Three of the major problems posed by on-farm tests of technology are high variance, bias, and insufficient field staff who are adequately trained and supervised. There are a number of approaches to reduce their impact.

High variance

The principal sources of variability in on-farm tests are environmental differences between and within sites and the differences in management by participants. Rather than masking intersite soil variability through uniform basal doses of fertilizer as in on-station trials, on-farm tests have as one of their objectives explaining performance variability as a function of environment. This can be done if one characterizes the microenvironment and incorporates such site characteristics in yield and returns analysis.

The method normally used to reduce the effects of within-site variance in researcher-managed trials on farms is increasing the treatment replications, whereas this approach is too complex for farmer-managed tests, the sites themselves often serving as replications. Thus, a more workable approach is to include large plots and to harvest treatment plots completely rather than to use yield samples to estimate production. As is the case for different sites, soils for individual treatment plots need to be characterized and included as performance determinants in subsequent analyses.

Although farmer modifications in recommended practices constitute an essential element in farmer-managed tests, they generally increase substantially the variability between sites. Consequently, the quality and the timing of all key operations on the farms need to be identified through interviews and frequent observations at the sites.

As farmer participation in tests increases, analytical methods based on traditional experimental designs become increasingly less appropriate and are replaced by methods developed for the analysis of data from cross-sectional surveys. Multivariate approaches that identify the direct effects as well as interactions of environment and management become essential. Depending on the availability of computing equipment, these approaches can vary from simple tests of mean differences with poststratification of cases to complex multiple-regression analysis. The number of observations (sites) to support these types of analysis must be large to preserve adequate degrees of freedom.

Bias

At least three types of bias, often present in on-farm tests, can seriously jeopardize the validity of the results: biased behaviour in the management of farmers' tests, biased reporting by farmers of operations performed, and biased subjective assessments of new technologies.

The first source of bias occurs when production objectives differ between farmers' test plots and farmers' traditional fields. If, for example, farmers believe that special status is to be gained through high yields on the test plots, additional inputs and management attention may be provided that would not be replicated if the technologies were adopted. If, in contrast, farmers consider the tests not as their own fields but rather as additional work imposed on them by "outsiders," the opposite bias would occur.

The misreporting of activities performed and biased subjective assessments derive from farmers' misconceptions of researchers' objectives and, consequently, from their desire to respond to questions in a way that they believe will please the researchers. Thus, despite being assured that modifications in recommended treatments are perfectly acceptable, farmers are often reluctant to report such changes.

Bias in farmers' subjective assessments of technologies usually stems from exposure to "development" interventions brought by outsiders. Most farmers initially fail to understand the experimental nature of on-farm tests and that they can actively critique technologies without offense to researchers and without jeopardizing their continued participation.

For each type of bias, the problem for the on-farm researcher is, first, to identify the presence, direction, and magnitude of biases, and, second, to reduce their effects. Identifying the biases requires close objective verification of all key on-farm test data. For example, to identify biases in behaviour requires systematically comparing test-plot management with management in other fields; to identify biases in the reporting of work performed requires frequent on-site verification; and to identify biases in farmers' subjective assessments requires the use of checks through which subjective assessments can be compared with objective measures of identical elements.

Over time, these biases tend to disappear as farmers understand more clearly the purposes of the on-farm tests and as they perceive these tests more as their own. Thus, researchers need to be patient as well as cautious in interpreting early results. Also, they should regularly explain the nature of their work and interact with farmers in a way that encourages open and frank dialogue.

Staffing and supervision

Most types of on-farm research pose substantially greater problems in staffing and supervision than are encountered in on-station research. Whereas researchers can daily direct and correct the work of staff at the research station, field staff assigned to villages must often work independently and be able to take appropriate decisions without consulting researchers. In addition to taking technical observations, village staff must be skilled in developing and maintaining both social and professional rapport with farmers. Finally, such staff must be willing to live for prolonged periods under village conditions.

For all of these reasons, field staff must be recruited carefully and trained well. Their responsibilities must be precisely defined and their workloads sufficiently flexible to allow for changing seasonal requirements and unexpected problems. At ICRISAT, for example, a ratio of about 25 farmers/field agent is nearly maximum if observations of farmers' tests and

collection of baseline data are to be done weekly. And an incentive system that reflects differences in living and working conditions between field and station-based staff is necessary to maintain morale and motivation.

Perhaps most essential in maintaining accuracy and efficiency in a program of on-farm testing, however, is that the researchers themselves frequently visit and stay in the villages. There is no substitute for personal input in following the seasonal evolution of the tests, in verifying observations and data registation, and in discussing with farmers and field staff their problems and impressions. On-farm testing programs cannot be directed from a distance. Rather, the researchers' close, frequent, and personal contact is absolutely necessary to ensure accurate data and valid interpretation and to maintain the commitment of field staff and, most importantly, of the farmers.

Experiences with rice in West Africa

K. Prakah-Asante, Anoop S. Sandhu, and Dunstan S.C. Spencer,
West Africa Rice Development Association, Monrovia, Liberia

The West Africa Rice Development Association (WARDA) has developed a model for technology assessment and transfer (TAT) to farmers in the region. It comprises four phases. The first is a survey and analysis of existing farming systems, with special attention to the social, economic, and production constraints faced by rice farmers. During this phase, new technologies are evaluated by the researchers.

In phase 2, components of technical packages from the research being done at regional research stations are tested in farmers' fields in relatively small plots (usually less than 100 m^2). These on-farm experiments are usually researcher managed, with the farmer providing only the land and labour.

In phase 3, the packages that showed promise in phase 2 are tested in large plots (usually more than 1000 m^2) under farm conditions and are evaluated against criteria specially developed for the purpose. These experiments are called adaptive trials and farmers participate directly in their management, e.g., in site selection, timing of operations, etc.

Phase 4 involves designing an extension strategy and setting up farm demonstrations in conjunction with the national extension services in the member countries, who are responsible for actual extension work. WARDA includes this phase in its mandate because most African states have inadequate extension education and lack facilities for experimentation and research to evolve an effective strategy for transferring improved technology to the thousands of farmers spread throughout the countryside.

The technology package

From the results of WARDA's special research projects, on-farm experiments, coordinated variety trials, and other national research programs operating in the region, a multidisciplinary team at WARDA compiles technology packages and assesses whether they will:

- Improve not only productivity but also profitability;
- Suit local agroclimatic conditions and ecology;
- Be acceptable to the farming community with regard to labour and production requirements and socioeconomic conditions;
- Qualify for governmental assistance as needed when taken up by national extension services; and

- Be based on inputs that will be available to farmers at the time they are needed.

In theory, innovations that do not fulfill these requirements are not pursued. The others are tested in adaptive trials in farmers' fields. However, sometimes in practice, the approach is slightly different. For example, a package for the mangrove swamp areas in Sierra Leone was identified and assessed. It included an improved variety of rice, mechanical land preparation, and fertilizer injection. The TAT team at WARDA concluded that the complete package was beyond the financial means of some farmers. The yields obtained in experimental plots as well as in preextension trials on farms sometimes did not offset the costs of the single axle power tiller. However, the baseline socioeconomic survey indicated that the farmers had a keen interest in the tiller, on the basis of their limited experience with it during preextension trials, and saw it as a means for reducing the drudgery of manual land preparation and expanding their farms. As a result, this item was retained in the package.

Keeping in mind that farmers often adopt improved technology in bits and pieces, the team divided the package into four subpackages — namely the improved variety alone; the improved variety and mechanical land preparation; the improved variety and fertilizer application; and the improved variety, mechanical land preparation, and fertilizer application. The improved varieties selected were ROK 5 (for areas with a short cropping season) and CP 4.

Adaptive trials

Trials in farmers' fields have fewer management controls than do those in research stations, with the result being higher experimental error and probably increased failure. Consequently, large plots and many farms are needed for adequate assessment. In WARDA's adaptive trials, plots measuring 4000 m^2 are recommended, with half being cropped in a traditional manner.

However, the average size of rice fields in a target area cannot be ignored. For example, many of the fields in the mangrove swamp rice areas in Sierra Leone are less than 4000 m^2 and the size of large fields is often difficult to estimate because creeks run through them. A more realistic size for WARDA's tests was deemed to be 2000 m^2 in some cases. Similarly, in the mangrove swamp rice areas in Guinea, the rice fields are comparatively small so a plot size of 1000 m^2 was adopted for the trials.

Based on information obtained from a survey of existing cropping systems, agroclimatic conditions, input levels commonly used by farmers, and yields obtained in a selected area, WARDA staff select sites. The idea is to ensure that results obtained are applicable to other areas with similar environments and cropping patterns. Other important factors taken into consideration in selection include the economic and political status of the farmers and the accessibility of their fields. Traditional leaders in selected communities are consulted tactfully in the process of selection of farmers or sites. The objective is to ensure that selected farmers are representative of the community and fit into it in a way that would allow other farmers to visit their fields and to see what is being done there.

The farmers who conduct the adaptive trials decide where they will establish the plots within their fields, although researchers provide input in an attempt to ensure the plot is representative of the farmer's fields. Farmers are taking a risk when they test a package, and they are sometimes understandably hesitant to use their best lands. There are other considerations as well. For example, farmers prepare their fields in March in the mangrove swamp area along the Great Scarcies River in Sierra Leone, and, in the first year of adaptive trials, the farms to be included were not selected until May–June. Plot sites offered by farmers were not truly representative and, in some cases, were submarginal, often heavily weed infested, infertile, or were subject to damage from crabs because of their proximity to the river. As the farmers had already plowed their good fields and the adaptive trials were just beginning, the farmers were reluctant to use their good lands for the trials. Poor trial sites are not necessarily a bad thing: packages that perform well under these conditions have a good chance of performing even better on good sites.

Variability among farms is generally expected to be greater than that within a farm. Thus, using a large number of farms is usually more desirable than having replications within a farm. The number of farms needed for a particular technology depends upon the variations among farms in an area. Normally, 10–15 trials are considered sufficient for proper assessment of each package within a homogenous area. This number provides sufficient variation in yield data for researchers to determine the risk involved in adopting a technology.

Initially, WARDA decided to conduct only one trial/village and to spread the program to a large number of villages. This was practicable in the mangrove swamp areas in Sierra Leone but not in the floating rice areas in Mali where villages in the Mopti zone are located on high ground and are far from each other. Fields are sometimes 16 km from the village, and farmers have to travel by boat during the flood season. Introducing 3–4 trials/village increased the possibility that farmers in the area would become familiar with the technology. During the crop season, all inputs except for the components of the technology package are provided by the farmers themselves. The farmers keep all the produce from the trial plots and are guaranteed compensation if the improved package yields less than the traditional practice.

Farmers manage the trials with advice from extension personnel and researchers as to the proper application of the new and improved technology. They are free to make small changes in the packages, e.g., dates of planting, weeding practice, harvesting time, etc. but are encouraged to perform all practices on time.

The trials are publicized within each village so that other farmers become aware of the nature and purpose of the trials. The openness helps remove any misgivings among them, and they are encouraged to visit and, later, to comment on the trials.

All these steps were followed in 40 adaptive trials of the four improved technological packages in Sierra Leone. The salt-free period available for rice cultivation in mangrove swamp areas is 4–6 months; the variety used was ROK 5. The tiller was used for plowing and, a month later, puddling. Fertilizer treatment involved injection of a 30% aqueous solution of urea at the rate of 40 kg N/ha applied at early tillering, 30 cm below the soil surface.

Modifications to the package

WARDA evaluates the performance of the packages on the basis of yield data, economic benefits, and social criteria (including labour-use compatibility), risk, and acceptance in terms of the farmers' likes, tastes, and attitudes. The yield data are taken from both the control and the improved plots, a minimum of 500 m^2 each, and from random samples of the farmers' field outside the trial plots. Soil characteristics, climatic factors, rainfall distribution, plant-protection measures, etc., are also recorded throughout the growing season to explain any unusual situation that may affect yields.

For economic analysis, the total labour input is costed at the prevailing wage rate, and the costs of other inputs are noted. There is substantial seasonal variation in paddy prices. For example, in Sierra Leone, the price varied from Le6 to Le20 per bushel (ca 35 L) during 1982–83. To obtain credit before harvest, farmers had agreed to accept the lower price, whereas the higher price was in effect just before harvest. The farm-gate price, which at harvest is usually used in WARDA's economic analyses, was Le10.

For comparisons on labour-use compatibility, the labour input by month is recorded for each operation. Labour inputs are recorded carefully at the trial sites for all operations. This record allows a good comparison of the total labour requirements, as well as labour distribution, for the improved versus existing practices.

After harvest, farmers are asked how they would rate the grain's appearance, taste, cooking and storage quality, etc., as well as whether or not they would like to use the packages on their own in the next season. This information provides insights regarding the production technologies in terms of farmers' needs and resources.

All the information is analyzed as a basis for any modifications in a package to be recommended for extension by national programs. For

Table 1. Results from 40 adaptive trials conducted with four improved technical packages in mangrove swamp areas in Sierra Leone during 1982.

Assessment criteria	Technical package			
	Variety	Variety, mechanization	Variety, fertilizer	Complete package
Yield (kg/ha)				
Traditional practice	695	1573	1574	2044
Improved package	1418	1716	2232	2785
% increase	104	9	41	36
Net revenues (Le/ha)				
Traditional practice	-201	125.50	187.25	298.25
Improved package	-6.50	71.75	266.75	376.25
% increase	96	-42	42	26
Labour requirements (workdays/ha)				
Traditional practice	198	198	198	198
Improved package	215	168	206	193
% increase	8	-15	4	-2

example, in Sierra Leone, based on the yield performance and economic analysis (Table 1), tentative conclusions were that:

- The improved variety could be grown alone or with fertilizer and would increase net revenue by more than 40%;
- Mechanical land preparation was barely profitable but would reduce the drudgery of hand weeding; and
- The complete package could be expected to increase the revenues by about 25%, thus reducing drudgery of hand digging at the same time as farm income is increased.

The results of labour-use analysis indicated that there was not much difference in the labour requirements between the traditional practice and the improved packages. However, use of power tillers for land preparation and puddling reduced labour by about 15%. Hence, the improved packages were compatible with the traditional practice in terms of their labour requirements. The farmers' enthusiasm for the tiller has prompted WARDA to continue working with this technology and to attempt to devise ways in which it could be put at the disposal of farmers at minimum cost.

Results of the opinion survey indicated that farmers liked the grain appearance, taste, and cooking quality of the improved variety. The majority said they were willing to adopt the improved variety alone or in combination with fertilizer or mechanical plowing.

Some farmers expressed reservations about growing ROK 5, as it matures 20 days earlier than their traditional varieties and, hence, requires special arrangements for bird scaring at additional cost. Others liked it, as it would provide food for their family at a time of traditional food shortage. Detailed analysis showed that farmers who had fields close to their homes appreciated it but that the others needed a variety that took longer to mature.

In areas where the later maturing improved variety — CP 4 — was used, farmers expressed some dissatisfaction because of the variety's shattering, which reduced yield and made harvesting difficult. The research team has, thus, replaced this variety with ROK 10.

Extension-education strategies

On the basis of the adaptive trials, WARDA staff separate technologies into three groups:

- Those that pass all criteria and are recommended to the extension services for all farms in the target region;
- Those that pass assessment criteria only for farms with certain characteristics and, therefore, are appropriate for extension only with certain restrictions; and
- Those that do not pass assessment criteria and are returned to the biological scientists for further investigation or modifications.

When technologies with restricted application are recommended to national extension services, all the limitations are clearly stated, and, sometimes, extension-education strategies are recommended. For example, because of the heavy initial investment needed for the use of power tillers in mangrove swamp areas of Rokupr, Sierra Leone, the TAT team recognized

that individual farmers could not afford to adopt it. Thus, three pilot farmer groups were established in 1983 in the areas. The objective was to test whether cooperative use of the fertilizer injector and single-axle power tillers was feasible. Guidelines for the cooperatives were prepared, and credit provided to them for purchase of the equipment. Each cooperative was expected to group enough farmers to cultivate 24 ha, i.e., 20–30 farmers, the area calculated to ensure reasonable returns for one power tiller. Farmers were to pay a membership fee of Le50 each, which would provide a 35% down payment for each tiller and 2–4 injectors. In addition, they would pay a fee of about Le173/ha cultivated, almost 75% above the estimated cost of hand cultivation. A power tiller operator nominated by each group is to be trained by WARDA, and the group is to select its own chairperson, secretary, and treasurer.

The three cooperatives are in their first year of operation. The farmers modified the recommended guidelines to suit their needs from the outset. In one case, fewer farmers than recommended got together and paid a higher membership fee. In another case, the farmers decided to rent their tiller to nonmembers. Further developments of the cooperatives are being monitored.

Concluding remarks

WARDA focuses its research program on four rice ecologies in the region. These ecologies are mangrove swamp rice, deep-water and floating rice, upland rice, and irrigated rice. Socioeconomic surveys have been completed in the mangrove swamp rice areas of Sierra Leone, Guinea, and the Gambia, and in the deep-water and floating rice areas of Mopti, Mali. Similar surveys are in progress for the mangrove swamp rice areas in Guinea Bissau, upland rice in Bouaké, Ivory Coast, irrigated rice areas in Richard Toll, Senegal, and Upper Volta.

Improved technological packages have been identified for mangrove swamp rice in Sierra Leone, Gambia, and Guinea, and for the deep-water and floating rice areas of Mopti, Mali. Some packages were tested in adaptive farmer-field trials at Rokupr, Sierra Leone, in 1982. Others are being tested at other locations in 1983. Detailed methodological considerations and assessment criteria have been worked out for the adaptive trials.

In the planning for and conduct of all these trials, farmers have a heavy input. Based on the results obtained in the mangrove swamp areas of Rokupr, Sierra Leone, from 40 adaptive trials conducted in 1982, production packages have been modified and an extension strategy has been designed and is being tested this year. Thus, the improved production packages are being modified to meet farmers' needs and resources and an extension-education strategy suitable to farmers' conditions and capable of being adopted by the extension service of the country is being developed.

Experiences from northern Nigeria

G.O.I. Abalu, A.O. Ogungbile, and N. Fisher, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria

Nigerian agricultural administrators are increasingly concerned that peasant agriculture in the country has developed little over the years and that it is presently incapable of solving the nation's food problems. Although research centres in the country have demonstrated that it is possible to grow high yields by using improved varieties, fertilizers, protection chemicals, and high plant populations (Fisher et al. 1982), most farmers have been unwilling or unable to adopt resulting technologies. Factors responsible for yield gaps between the research station and farmers are technical, economic, and social. The technical factors include differences in soil quality and management ability as well as conflicts of the new practices with other technical elements in the farmers' production systems. The common economic and social factors include higher costs associated with the new inputs, differences in production objectives, lack of complementary resources, inadequate infrastructural and institutional support, taste preferences, and conflicts with social obligations.

These factors do not obtain in every situation, and some are more important than others. The extent to which they limit farmers' adoption of a new technology, and hence the evaluation of it, will vary from one technology to another.

Farming-systems research has promise as a means of achieving technological improvements in peasant farms and thus bridging the gap between on-station and on-farm conditions.

Theoretically, farming-systems research is concerned with the land, the structure of farms and fields, the climate, soil fertility, the labour resource and how it is used, the capital available for farm improvement, and the relationships with input delivery, extension, and marketing services. In practice, however, this is far too vague, and farming-systems researchers increasingly are focusing on the constraints and testing technologies that might alleviate them. The steps suggested by Fisher and Lagoke (1982) are relevant for the Nigerian context:

- Identify the constraints operating to limit output of a particular farming system, usually represented by a target area of a size not greater than a local government area.
- Evaluate, on the basis of existing information, technologies that might overcome the most important constraints, not so much from the viewpoint of their biological or technical efficiency but from the

viewpoint of whether or not they are appropriate for use by the farmers in the target area.

- Test, usually on farmers' fields, the technologies that appear to be appropriate and then either reject them and try something else; modify them and try again; or accept them and propose the necessary institutional action to facilitate their adoption (extension, input, delivery, marketing).
- Monitor adoption, continue to modify the technology as necessary; be prepared to try something else if the technology is not widely adopted; or if the technology is being adopted, identify and propose solutions for the next most important constraint.

The approach differs from conventional crop-improvement strategies in that it begins with and ends with the value system of the farmer. In this way it provides an opportunity for farmers to articulate their felt needs, thus making research and technology development more appropriate.

Evolution of farming-systems research in northern Nigeria

Although farming-systems research has only recently gained widespread interest, it has had a long history in northern Nigeria. As early as 1958, researchers at the Institute for Agricultural Research (IAR) at Samaru had shown concern for farmers' rejection of many of the recommendations that were emanating from the institute's work (Gisborne and King 1958). The researchers argued that the advice being given by the research division at that time on how to produce the highest possible yields per hectare of a particular crop could not and must not be interpreted as defining how best that particular crop may be fitted into the existing pattern of peasant agriculture.

In 1965, a Rural Economy Research Unit (RERU) was set up at the institute to perform the task of finding out what peasant farmers in the area were doing, why they did things the way they did, what they ought to be doing, and the best way to get them to follow appropriate practices. Norman's (1972) pioneer work in this area provided a definitive diagnostic survey of peasant agriculture in the area. It was later followed by a series of feasibility studies that were designed to determine the technical, economic, and social feasibility of improved technological packages under farmers' conditions. The studies were essentially ex-post, on-farm trials of technologies designed by scientists without reference to farm conditions. The results of the tests were passed to the scientists for further refinement of the technologies. Thus, farmer participation was restricted to the evaluation of the technology.

Lately, an attempt is being made in the institute to get farmers involved much earlier in technology development. To this end, two types of research projects involve farmer participation: those being carried out within the commodity-based programs and those carried out under the farming-systems research program.

This setup has two advantages: it ensures that the program leaders of the commodity-based programs have direct control over research on crops of interest to their programs, and it establishes a direct link between the crop-based programs and the farming-systems research program.

The farming-systems research program focuses on immediate solutions for specific local problems and conditions on the basis of an understanding of the farming systems and their constraints. The on-farm studies in the crop-based program emphasize development of prototype crop technologies. These are aimed at major increases in the potential productivity of farming systems within the institute's sphere of influence.

Technology evaluation

There is evidence of selective adoption of new technologies by farmers in northern Nigeria: they have readily adopted improved maize but not improved millet or sorghum. Likewise, farmers in the area have readily accepted the use of fertilizers on sorghum and millet but rejected other elements of the package such as "improved varieties," the practice of sole cropping, and closer spacings.

At IAR, we don't yet know why farmers choose some components and not others, but the selectivity indicates that they apply a set of criteria including:

- Yield performance;
- The quality of output and their preference for it;
- The ease with which they are able to carry out recommended cultural practices;
- The adequacy of recommended amounts of improved inputs;
- The technology's demands (amount and timing) on the resources available to the farmers; and
- The financial and economic returns from new technology compared with other activities competing for farmers' resources.

IAR has developed methods of evaluating new technology under farmers' conditions, which utilize these criteria as applied by farmers.

In the early 1960s, several on-farm fertilizer trials were carried out at IAR (Fisher 1982). The only distinguishing element of these trials was that they were located on farmers' fields or on farm centres controlled by the Ministry of Agriculture. The experiments were located on farms where Ministry staff could regularly visit and control them.

A more recent series of similar trials was carried out between 1973 and 1976 (Fisher 1982) to compare fertilizers used alone and in combination at the recommended rates for maize. There were five treatments replicated five times, with the experimental site being moved to a new location within the same area each year.

Several experiments involving comparisons between improved packages and traditionally grown crops have also been carried out. In 1965 and 1966, about 800 groundnut demonstration plots were grown alongside traditionally grown groundnuts for comparison purposes (Harkness 1970). The experiments were sometimes simultaneously carried out at the institute, incorporating a range of evaluation criteria not possible in the design of the on-farm trials. For example, traditionally grown crop mixtures have been compared with crop mixtures involving improved varieties, seed dressing, different plant spacings, and fertilizer applications. Traditional versus improved packages of cotton, sorghum, maize, and cowpeas have also been

compared to determine the technical, social, and economic feasibility of the improved packages. In a number of cases, attempts were also made to determine the factors responsible for any observed differences and to seek farmers' opinions.

Attention is increasingly being focused on diagnostic surveys aimed at identifying constraints existing in major farming systems in northern Nigeria, understanding these systems, and using the information to shape the design of new technologies appropriate for the system. These new technologies are then taken back to the farmers for evaluation, and the process is repeated until widespread adoption of the technology.

Work has been completed on a diagnostic survey of the millet-dominated cropping systems of the drier northern portions of the country. A World Bank-assisted development project located in the area is already using the results of this diagnostic survey as a basis for its own adaptive research to ensure widespread adoption of its improved packages. This cooperation is quite informal and unique; for political and bureaucratic reasons, coordinated efforts between such projects and national centres are rare.

Statistical designs and plot sizes

No evaluation method can be universally suitable. Rather, goals, targets, and expectations associated with a new technology should shape the design.

If the objectives of the evaluation are purely technical, simple on-farm experiments may suffice. However, researcher-managed trials, especially for inputs, such as herbicides, where dosage is critical or special equipment essential, produce little or no useful information on the appropriateness of the technology (Fisher 1982).

If the objective of evaluation is essentially socioeconomic, then tests that compare traditional and improved techniques are probably more appropriate, especially when they are managed by the farmers. The control is the traditional way of growing the crop or producing the animal, but other comparisons are possible. For example, farmers given inputs and advice on a technology, with the freedom to modify recommended practices, could be compared (on the basis not only of management and production but also of adoption) with farmers who have been compelled to follow the recommended practices.

Ideally, plots are large to reflect farmers' conditions as closely as possible, but such plots are costly to manage. The rule of thumb at IAR is that plots should be large enough to make the treatments realistic for farm conditions and to provide adequate data for statistical analyses. IAR studies sometimes sacrifice replications so that the size of the plots can be increased, although the replications over time are essential to test the stability of a proposed package. For example, in evaluation studies at Zaria, improved cowpea packages worked well on farmers' plots the first year but failed in subsequent years (Hays et al. 1977).

In most of the studies carried out in Zaria, "a package of recommendations" has been at the centre of the statistical design. This is also true of many evaluation studies carried out elsewhere, but farmers often choose to adopt only certain elements of a package. In the four original agricultural-

Consumers in Nigeria prefer large, white cowpeas so farmers may not be interested in producing the hardy, small, brown ones.

development project areas in Nigeria, for example, fertilizer use has been widely adopted but not recommended spacings (Daplyn and Poate 1981). The problem is that, in package technologies, the researchers usually fail to communicate to farmers the benefits of the various components of the package. The impression is often given by package-oriented designs that unless the farmers adopt all elements, they cannot improve output. In fact, scientists often design packages even when they have no evidence that the components interact positively and even when they believe that a single factor is overwhelmingly important (Fisher 1982).

As new techniques are often adopted piecemeal, I believe that researchers should stop packaging technologies unless they can provide analyses of the costs and benefits of each of the components. Researchers in East Africa have taken a step in the right direction with their so-called maize diamonds, utilizing minifactorial demonstrations with 2^n treatments where n is usually 2 but is sometimes more (Fisher 1982). The scope of this design could be enlarged to include two factors, say, an improved variety and improved husbandry (fertilizer, closer spacing, more timely planting, more timely weeding) and four plots, one each for unimproved variety; improved husbandry; improved variety; and improved husbandry and variety. Further evaluation might include socioeconomic factors; for example, the farmers

could be provided with credit to purchase the technology; with input delivery; with extension; with credit and extension; with credit and input delivery; with input-delivery and extension; with credit, extension, and input-delivery.

Securing farmer cooperation

No evaluation can be successful without the active cooperation of farmers, and there are some simple steps that can be taken to avoid the pitfalls of providing a technology that is not viewed by the farmers as promising in some way. Most farmers quite willingly participate in an evaluation exercise when they believe that their efforts will be offset by the potential benefits. However, if they lack conviction that the technique has potential, they are likely to view evaluation more as an opportunity to obtain inputs free than as a partnership.

Because the technologies that are the subject of farmer evaluation are new and often shrouded in some amount of uncertainty, one way to encourage farmers to participate is to provide guarantees and subsidies. However, what effects these incentives have on the results of the evaluation exercise is not certain. If farmers are given all the needed inputs and advice free and are coerced into following the recommended practices, they may achieve performances closer to those obtained at the research centre. But their performance probably couldn't be repeated on a wide scale. Also, the evaluations obtained under such circumstances would likely be distorted. If subsidies are too high and if farmers are not coerced into following the recommended practices, they may waste the inputs or use them for other purposes.

If the final output from the new technology is not likely to be readily sold or consumed, the farmer is unlikely to participate. Recently, for example, a sorghum variety developed at IAR was used in farmers' tests, even though the demand was nil because people did not like its taste.

There must also be an assured supply of inputs. If the needed inputs are available but difficult to obtain, farmer participation will probably only be secured if the efforts expended in procuring the inputs are more than offset by the perceived benefits of the technology.

Finally, the researchers themselves must have confidence in the technology. They should be able to "stick their necks out" to a reasonable extent in establishing its strengths and weaknesses. Also, they must be willing to explain what they are expecting from the technology, and they must have built up enough rapport with the farmers to obtain honest input and opinions. Farmers are often left in the dark about the objectives of evaluation and quite naturally view the studies as outsiders' projects.

Involving farmers in the evaluation of any new technology must be carefully planned, meticulously executed, and constantly monitored if farm testing is to be more than just an extension exercise.

Experimental approaches in southern Mali

Paul Kleene, *Royal Tropical Institute, Bamako, Mali*

Since 1979, the rural farming-systems research division (DRSPR) of the Institut d'économie rurale has been responsible for multidisciplinary studies and research to analyze Mali's farming systems and design means to improve these systems. The division selected the southern part of the country for the introduction of the first programs because agricultural potential is good, crop and livestock production are highly integrated, there is a willingness to innovate in the area of technology adoption and extension, agriculture has developed rapidly, significant disparities have resulted from this progress, and the region's roads are perhaps the best in Mali.

The headquarters of the DRSPR are in Sikasso; at the end of 1982, the division had a staff of 64, including 16 researchers. Because of the complexity of agricultural activities, rural teams of agronomists, biologists, sociologists, and agroeconomists have been formed. Specialists from other disciplines are called upon as required for specific studies and for collaborative activities such as studies of grazing land, soil conservation, and agricultural extension.

The division is currently carrying out two projects. The Fonsébougou project, involving seven villages (in 1983), is funded jointly by Mali and the Netherlands and is being implemented in cooperation with the Royal Tropical Institute (RTI) of Amsterdam. Efforts will be directed primarily toward the integration of crop- and livestock-raising, erosion prevention, description of farm types, and farm counseling. The Bougouni–Sikasso project involves three villages and is funded jointly by Mali and the International Development Research Centre (IDRC). The main tasks will be on-farm tests, follow-up studies, and surveys. The activities are to be extended to other ecological zones in Mali.

Some tests are conducted in a controlled environment at the Tiérouala research station, but most of Mali's farming-systems research activities are carried out in 10 selected villages (Fig. 1). They are linked with the Malian textile development company (CMDT), which is responsible for the region's integrated development. This collaboration between research and development was confirmed in 1982 by a memorandum of agreement. Farming-systems research in Mali is, thus, ideally set up to promote dialogue between farmers, researchers, and development workers.

In the division, our main experiences with farmer participation have been through agronomic tests, full-scale demonstrations, and farm counsel-

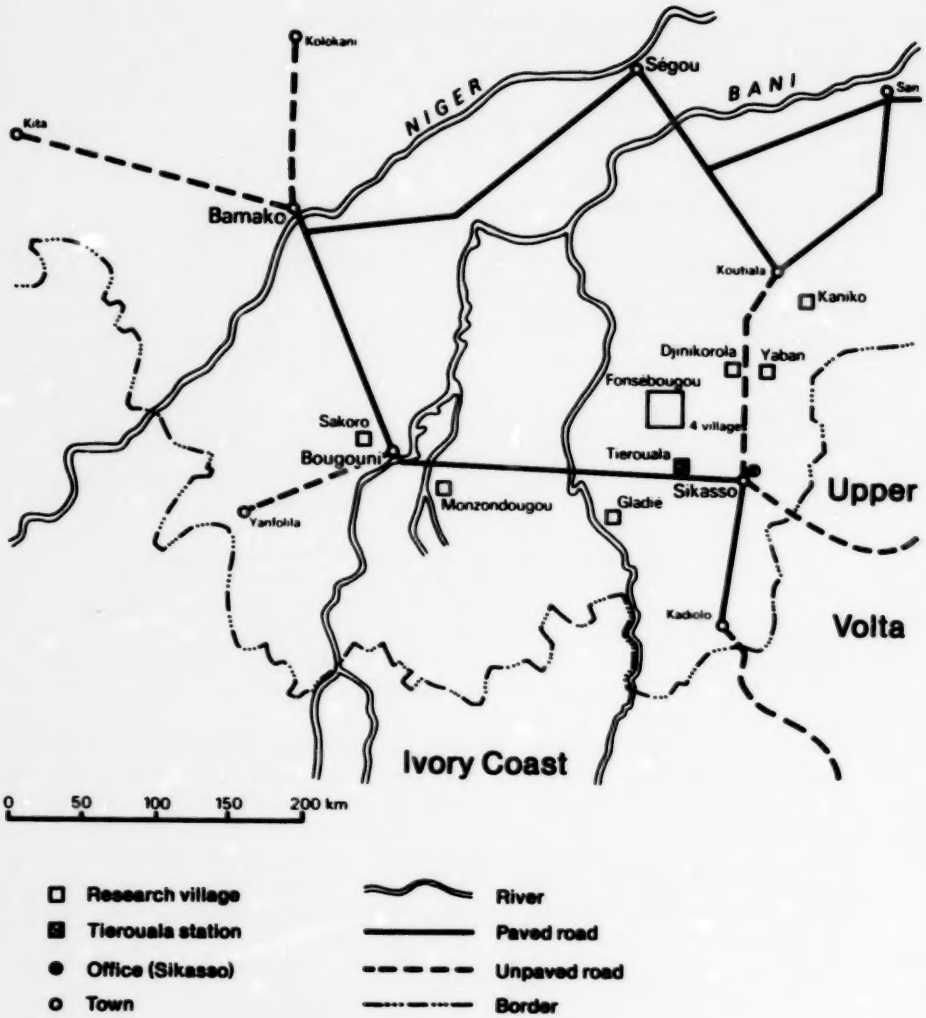


Fig. 1. Geographical framework for farm counseling.

ing. Within these experiences, farmers have participated in the design, the implementation, and the evaluation of technologies.

Agronomic tests

The role of agronomic testing has been evolving. This tool is now used both in thematic research and in agronomic research for development projects; this is the case in the SAFGRAD program and the maize component of the southern Mali/CMDT project.

Both researcher-managed and farmer-managed tests (Gilbert et al. 1980) are undertaken. Researcher-managed trials focus on particular technical problems. Plans for the experiments are drawn up in advance and implemented as faithfully as possible. Land and services for the research are borrowed from the farmer, who is a vital partner for ecological–environment reasons but does not contribute to the management of tests. As the tests "belong" to the researchers, farmers receive payments or other incentives. During 1983–84, some researcher-managed trials of soil fertility began on farmers' fields that had been producing crops for a number of years. The farmers participate in the research tests under contract and are remunerated in one way or another for their services. In areas where this form of contract is unfamiliar, it might be a source of misunderstanding between partners. The farmers cannot be expected to show much interest in the research "gardens," as they cannot easily interpret the results and are unable to apply them directly.

The DRSPR acts as executing partner. In this work, it has the advantage of being present on site and having credibility among the farmers. However, paying farmers is the source of some controversy as some people believe it will hamper other farming-systems research activities.

Although we in the division are convinced that this type of testing is worthwhile, we feel that farmer-managed tests — thematic research — should provide the scientific framework.

Farmer-managed tests within the agronomy program are proposed by researchers but carried out by farmers and are the type most used by the Malian DRSPR. Difficulties encountered with these tests have helped clarify the limits of this tool.

The objective of these tests, as they are conducted in southern Mali, is to find a technical solution to a socioeconomic or technical constraint identified in the real environment. They differ from demonstrations in that their results can be verified agronomically.

However, efforts to alleviate a constraint felt by the farmer often conflict with attempts to be rigorous from a scientific point of view. Farmers volunteer to participate and are selected as being representative of the various types of production. Because conditions in subsistence farming are precarious, problems often arise in farmer-conducted tests. Participants implement experiments quite differently, and the results are often difficult to interpret in agronomic terms unless they have been drawn from a large sample and have been carefully monitored and screened.

Our experience has been that farmers participate readily in tests directed toward what they consider to be a major constraint. The research plan must be adequately discussed, the results jointly evaluated, the land area sufficiently large to simulate farmers' plots, and the number of treatments must be limited.

Ensuring farmers' participation in these tests is easier than in researcher-managed trials because the farmer is in charge and the researcher is seeking help. Continually reminding the farmers of the provisions of the plan reduces their real autonomy, but they interpret the plan in their own way. Their attitudes and involvement strongly depend on the relationship that they have with researchers (or intermediaries).

In cooperation with SAFGRAD, farmer-managed tests were carried out in 1979–80 on 0.25-ha plots divided into six subplots. As the farmers concerned had from 8 to 20 ha under cultivation, they thought little of the "gardens" and did not understand why there were so many treatments. The size of the test plot was important for another reason in areas where animal traction was used: small plots subdivided a number of times are difficult for the farmer to work.

Consequently, the test areas were increased to 0.5–1.0 ha divided into two subplots, one treated and one not. This approach conformed more closely with tests that the farmers have traditionally conducted themselves on density, fertilizer dosage, etc.

The inputs are supplied free of charge to promote consistent implementation of the plans in the farmer-managed tests. This practice ensures that the farmers don't suffer great hardship if experiments fail. For example, the cost of 300 kg of fertilizer spread over 0.5 ha in the current tests is significant. Nevertheless, there is some controversy about the payments because farmers who participate in the other two facets of the division's activities — demonstrations and farm counseling — in the same region are not given incentives.

The plots used for the agronomic tests are always considered by the farmers to be "research plots," but they play a useful role in the farmer–researcher dialogue. Farmers often participate in designing the trials and, above all, in evaluating them. The advantage of these tests is that both partners gain technical knowledge.

Demonstrations

"Full-scale demonstrations" mean the introduction of sets of technical innovations (packages). Although others refer to the introduction of *new* technologies, most of the technologies have been available for a long time.

What is new is the method of analyzing situations and selecting technologies to suit the needs of various types of farmers. Demonstrations differ from trials in that the results often cannot easily be compared with those in an untreated area. The difference in the results can be seen but not the role of each variable in obtaining the results.

For example, the success of efforts to keep draft animals in good condition during the dry season could not be attributed to any single improvement or combination of improvements, which included eliminating internal parasites, supplementing the animals' diets, introducing a salt lick, and watering. How could the benefits for work and the stamina and health of the cattle be measured? Group analyses did not give convincing results, and the weight of the animals was only a partial indicator.

However, the evaluation carried out by the farmers themselves, on the basis of empirical criteria, left no doubt as to the success of the undertaking. Thus, such experiments, over a number of consecutive years, can be evaluated in terms of the degree of farmer participation and the farmers' empirical criteria.

Although the results provide only indications and probabilities — information that is not scientifically verified or valid — the strategy is

promising for development. For example, in Fonsébougou village land, erosion from surface water is a major problem. The farmers are keenly aware of it and have tried to solve it by building small dikes to divert the water and narrow ditches to carry away runoff. The erosion is becoming worse each year because of land clearing, stump removal, brush burning, and so on. Under these circumstances, farming-systems research must deal with this problem. Why encourage the farmers to improve their livestock's condition and increase dung production if the dung is washed away almost as soon as it is spread?

Techniques to combat erosion exist, so a demonstration to introduce them in a way that involved the farmers as much as possible was planned. Except for topographical surveying, all the work was carried out by the farmers who sometimes called on village associations.

Little effort went into researching the technical aspects (measuring flow and so on). Emphasis was placed on finding a method permitting maximum farmer participation in the efforts. To date, about 100 ha on six farms have been improved by the farmers, who used only their own plows and "dabas" (hoes) to construct the 27 km of banks.

In my opinion, farmers have to participate if such full-scale demonstrations are to succeed. Participation cannot be taken for granted, but when farmers see advantages in a proposed technology, they will almost always adopt it. The potential for benefit from demonstrations hinges on efforts to increase farmers' awareness and on the quality of the work carried out initially. For this reason, I feel that full-scale demonstrations can be successful only if the policy of providing inputs at no cost to the farmer is abandoned. Demonstrations involve farmers in the implementation and evaluation of technology more than in design.

Farm counseling

Farm counseling evolved as part of the farming-systems research program to assist farmers in taking stock of their whole farm and developing an improvement strategy that may extend over a number of years (Kleene 1982).

In French-speaking West Africa, this method was developed principally within the framework of Senegalese experimental units (Richard 1974; Benoit-Cattin 1978). Experiences in Mali date from the 1980–81 crop year. Some 30 farms are now participating, half of these within the framework of preextension activities in cooperation with the Malian textile development company.

In the main, two categories of farm are involved: those without equipment whose owners want to progress to draft power through an equipment credit from the national agricultural development bank (BNDA), and those with equipment whose owners want to improve their production results.

The steps are: gathering data about the farm; analyzing and diagnosing the major problems; establishing objectives; planning the crop year; implementing the plan; and evaluating the results.

Model of local shelter for oxen, with stocking of fodder from above.

The early efforts in farm counseling used data gathered during surveys done by research teams. The farmers became involved only after the staff had diagnosed the problems and had drafted a plan for the crop year. One of the first benefits of this undertaking was the identification of relevant variables (Kleene 1982).

Farm counseling is of great interest to researchers and farmers alike and is an ideal framework for researcher–farmer cooperation. To increase farmers' involvement in data collection, diagnosis, and evaluation, CMDT became interested in an experiment to increase functional literacy.

In the village of Kaniko, 15 km east of Koutiala, 15 newly literate people who took courses in Bambara for 3 years were recruited to take part in farm counseling. In 1982–83, they measured fields and calculated yields as part of their literacy training. Missing data were supplied from measurements taken later or were estimated. The group has been compiling data, assessing the situation, and discussing crop-year plans. They also follow up results. These exchanges are extremely valuable and have had an immediate, positive impact on literacy training, farmers, research, and development. For one thing, they provided the opportunity and means for explaining to farmers the concept of yield and the difference between intensive and extensive practices, particularly where the use of inputs was concerned. Farm counseling in this village provided for maximal farmer participation in design, implementation, and evaluation.

Of course, conditions such as those at Kaniko are not found everywhere. In some cases, researchers and development personnel will play a greater role in farm counseling. Nevertheless, because of its flexibility and its relevance to the farmer, this method is highly instructive.

As is the case with demonstrations, farmers receive no payment or inputs free of charge. However, the farm-counseling program may include a short- or medium-term credit scheme in cooperation with the development organization and the BNDA.

Conclusions

Having outlined the three experimental approaches involving farmer participation in farming-systems research in southern Mali, I have a few final observations. The use of these various approaches in the same villages creates some problems. Villagers are disgruntled about the fact that some farmers are remunerated (researcher-managed trials), others obtain inputs at no cost (farmer-managed trials), and still others participate without receiving anything. They are not convinced that there are good reasons for this discrepancy, which they find unfair. Perhaps give-away policies are unnecessary anyway; farmers recognize that testing, like farming in general, involves risks. For this reason, the agronomic testing in the villages newly selected for preextension activities in conjunction with the CMDT is small, and the inputs are not free.

If farmer participation is used as a criterion, none of the approaches is fully satisfactory. All depend to some extent on outside support. Farmer-managed tests increase the level of participation by farmers in design, whereas demonstrations involve them more in implementation.

My view is that farm counseling offers the most possibilities for genuine cooperation between farmers, researchers, development, and extension workers. However, this approach also has its limitations, particularly when it comes to bringing it into general use because the level of participation depends on the skills of the farmers. More emphasis must, therefore, be placed on providing information, increasing awareness, and training the farmers to take advantage of what we can offer. To succeed, farming-systems research must closely cooperate not only with farmers but with the development organizations in a region.

We at DRSPR have found that visits organized between groups of farmers are an excellent way of increasing exchange. This type of activity and the problems involved in monitoring results can take a farming-systems research program away from its original aim of scientific research, but every opportunity to increase farmer participation in the evaluation should be seized, as the ultimate goal is improved production.

Tecnicista versus campesinista: praxis and theory of farmer involvement in agricultural research

Robert E. Rhoades, *Centro Internacional de la Papa, Lima, Peru*

The German sociologist Max Weber used a commonsense, fruitful way of analytically setting the stage for discussion of social phenomena. He proposed the notion of "ideal types," often conceptually polar extremes, from which researchers could investigate how empirical data vary from ideal forms. For example, Weber distinguished between *Gemeinschaft* and *Gesellschaft* to help clarify differences in social relations in intimate, informal groups (e.g., families, communities) versus the anonymity of large-scale, formal society (e.g., large cities, bureaucracy). This simple typology, in turn, generated a rich literature, as have other sociological ideal types, e.g., core–periphery, metropole–satellite, rural–urban, and developed–underdeveloped.

Weber's method is useful to discussions of the theoretical and practical aspects of farmer involvement in agricultural research. Contemplating the thousands of individuals who work in agricultural research and development directed toward Third-World farmers, one can distinguish two contrasting "ideal" perspectives. To identify these contrasting types, Peruvian scholars have recently coined the terms *campesinista* and *tecnicista*. A person who has a tendency to believe that farmers and *campesinos* (subsistence producers) have rationally adapted, with rural-based wisdom, solutions that cannot be measurably improved by outsiders is in the *campesinistas'* camp. According to this school, the truth is alive and well in the traditional practices of the countryside.

The *tecnicista* philosophy is followed by those who believe that scientists and formal research–extension organizations are a fountain of superior technological solutions and that answers to world hunger will come from science through controlled experimentation on research stations and direct transfer, to farmers, of the vast reserve of knowledge, technology, and basic principles that have already been discovered in advanced agroindustrial nations.

Any deserving student of Weber would argue that these ideal types do not exist, but most of us in agricultural development will agree that the Peruvians have put their fingers on a sensitive problem that penetrates many research organizations and projects. Even within interdisciplinary teams, different frameworks for defining the problems and ways of seeing the world are found. In practice, this often means that social scientists, especially the more academically oriented, tend toward the *campesinista* camp, whereas

technologists and applied biological scientists naturally have a leaning toward the *tecnicista* orientation.

Farmers, of course, are rarely *campesinistas* or *tecnicistas*. These terms refer to orientations of people who study farmers or have farmers as research "clients." Farmers know through day-to-day experience that they have serious technical problems for which no local answers are available. This explains why farmers are generally eagre to talk to visiting scientists about pests, diseases, varieties, chemicals, and a thousand and one day-to-day difficulties with the practices and technologies that serve to feed and clothe their families. At least in the Andes, peasant communities are growing increasingly impatient with outsiders who come to conduct agroeconomic interviews, administer long questionnaires, study antiquated practices, or run on-farm trials, while giving nothing in return. On the other hand, the reception is equally cold to the visiting "garland speeches" from technologists who ignore local practices and push ill-adapted technologies. Agricultural scientists who believe in applied research feel under strong pressure to have ready-made solutions and answers, but farmers catch on fast to those who try to bluff their way through a dialogue. They are quick to cast a jaundiced eye on those who are — as a Peruvian colleague put it — "promoting pet technologies in search of farmers, not offering technologies sought by farmers."

Potato storage in the Andes: a tecnicista approach

The potato is the main staple food of the mountain populations of the central Andes, the cradle of the tuber's domestication. Because of the potato's importance not only in the Peruvian diet but worldwide, considerable attention has been given to this crop by technical agricultural programs. Anthropologists have studied the agriculture of many Andean communities that depend on the potato. Until the establishment of the Centro Internacional de la Papa (CIP) in 1971, however, cross-fertilization of ideas between social and biological scientists was rare. As a result, most potato projects in the Andes were developed strictly from a technical point of view. Potato storage is a good example.

Since the late 1960s, the Peruvian government and various development agencies operating in Peru have sought technical solutions to help control the flow of consumer potatoes into the Lima market. As a result, the government built storage facilities around the country. The five large storages constructed had a combined total capacity of 2.0×10^4 t.

The largest of the storage complexes (7.0×10^3 t) is near the mining town of La Oroya, more than 3500 m above sea level. These naturally ventilated, forced-air stores were built to take advantage of the low temperatures and high humidities found at high altitudes between 1800 h and 0600 h (Fernandez 1976). The Oroya stores are located roughly halfway between the major potato-producing areas of the Department of Junin and the Lima market. On initial impression, the idea behind the stores makes good sense. Potatoes could be held at La Oroya with minimum losses until prices improved in July or August in the Lima market. Theoretically, everyone gained. Farmers could get higher prices than they would if forced to sell immediately at harvest in May. Consumers gained as well by having to pay lower prices during the "critical months" for potatoes.

Any traveler along Peru's central highway running from Lima to Huancayo, the capital of Junin department, can visit the impressive Oroya storage complex. However, it, and the others in highland Peru built during the same period and later, today stand empty, just as they have virtually every day since they were built. These stores are existing monuments to mistargeted development projects, although, according to storage specialists, they are technically sound and extremely well-designed. The failure resulted because the designers did not understand the postharvest system of potato agriculture as it functions in the central Andes. Such mistakes are not unique to Peru. Similar potato stores, technically sound but equally empty, can be found throughout the developing world.

Potato storage in the Andes: a campesinista approach

Outsiders entering an Andean house have the impression of total disorder. Across the main living area hangs a string of ears of corn; against the wall next to the bed are farm tools; below the bed are piled small, shriveled potatoes; and Guinea pigs scamper about the room, hiding behind the worn straw mat that holds the potatoes. It is easy to conclude, as does a recent FAO (Food and Agriculture Organization of the United Nations) proposal calling for more storage research in the Andes, that farmers' storage practices are inadequate.

Unlike in developed countries, potatoes in the Andes are rarely stored in separate, specialized buildings. In the early 1960s, an ethnographer (Stein 1961) noted:

> the main economic function of the house is storage of agricultural products and tools and it serves to shelter at least some of the animals as well. Its functions in sheltering people are almost secondary to the basic purposes.

The house offers security against thieves, and the darkened rooms hide one's wealth against the prying eyes of neighbours and employees of the agrarian bank. Virtually all the technical potato-storage programs, however, emphasized the need for specialized structures. Anthropologist Robert Werge (1980) wrote:

> Concentration on specialized constructions derives from use of a model based on the contemporary European and North American practice of keeping domestic and farm activities separate in specific houses, sheds or barns. Potato farmers in developed countries have highly sophisticated storage buildings with large scale capacities, often constructed with special financing. This model is not appropriate to the Andes. There farmers regard the storage of food, seed and tools as a domestic activity. The flexibility of space within the household residence and the security of the house is not compensated for by technical advantages which a specialized storage facility can provide.

A farmer from the community of Palca, within the area projected to use the stores, summed up his complaints, emphasizing labour costs for, and damage caused by, the extra stop enroute to Lima:

> *Ingeniero*, whose idea was it anyway to build those stores in Oroya? Once I start to Lima with my potatoes, why do I want to stop in Oroya, unload them, wait a month or so, and load them again? That is a lot of

> trouble, causes a lot of damage. Besides, the loss of weight will not compensate for the rise in price. If you want to build a store, build it where I live, not up there.

Along with market risk, farmers mentioned the risk associated with dealing with government bureaucracy. The few times the government did store in the Oroya silos, the potatoes spoiled and had to be thrown into the nearby Mantaro River.

Most Andean farmers, especially small-scale ones, do not store potatoes for market speculation. A catch-22 in the government storage scheme is that the agrarian credit bank demands repayment of production loans at harvest. Farmers, thus, sell off all except for what they wish to keep for home consumption or seed. In addition, farmers often must purchase inputs for the next planting or pay off other debts.

Finally, consumers prefer fresh potatoes, not potatoes that have been in store for 2–3 months. Also, some farmers argue that the improved varieties sold in the Lima market do not store sufficiently well to play a speculation game.

The simple facts make it easy to believe in the *campesinista* position, just as the *tecnicista*'s construction of the stores had its own logic. It is tempting to throw up one's hands and conclude all is futile. However, I believe that the trick is to combine elements from both perceptions: so that farmers can use science to its best advantage.

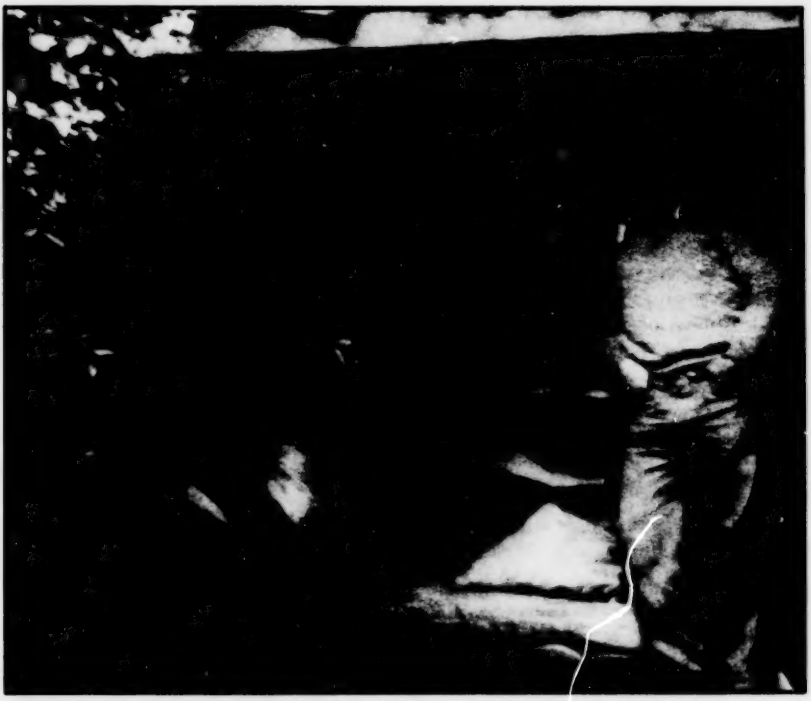
A new approach

In 1975, CIP took a new approach to solving Peruvian postharvest problems. The initial setting of this effort was the Mantaro valley where CIP's Andean research station is located. The empty stores of previous projects are scattered throughout the valley and 3 hours by car is the Oroya project.

In the early years of CIP, most postharvest research was carried out on the experiment station, without farmer or social-science input. Excellent technical research was under way, but the question was not asked whether the research addressed the farmers' problems as opposed to scientific questions. For example, one postharvest project dealt with solar drying of processed potatoes in a black box as a means to speed dehydration. The individuals who had decided to work on solar energy had not bothered to research whether speed of drying potatoes was important to Andean farmers. This is what the postharvest team now calls "designing technology at a distance" (Rhoades et al. 1982).

This lack of focus began to change with the formation of a truly interdisciplinary team composed of two postharvest technologists and anthropologists. This team set about to integrate the countryside with the experiment station in an effort to avoid previous failures. However, then, as now, combining views from farmers, biological scientists, and social scientists is not easy.

Initially, anthropologist Robert Werge conducted a socioeconomic survey of postharvest activities and problems facing highland potato farmers in the Mantaro valley (Werge 1977). The biological scientists still restricted their activities to conducting research trials on the experiment station nearby.



Peruvian farmer beside a 1-t store utilizing diffused light.

It was not clear how team members would relate to each other *or* the scientific team to farmers.

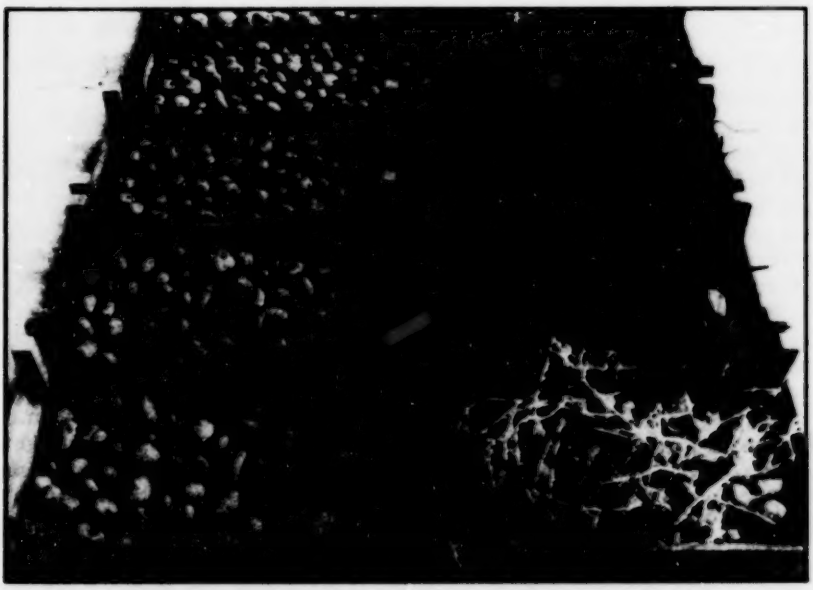
Werge's survey soon called into question some research directions that had been taken by biological scientists on the experiment station where controlled conditions are possible. A debate, or "constructive conflict," within the team then surfaced over the sacred concept of "storage losses," perhaps the central concern of many postharvest technologists and the basis of earlier Andean storage projects. The potato, a tuber, is highly perishable. Biological scientists were logically concerned with how to design a storage system to reduce pathological and physiological "losses." Werge, however, argued that Andean farmers did not necessarily perceive small or shriveled and spoiled potatoes as "losses" or "waste." All potatoes were used in some form. Potatoes that could not be sold, used for seed, or immediately consumed at home were fed to animals, mainly pigs, or processed into dehydrated potatoes, which could be stored for long periods. Women even claimed that shriveled, partially spoiled potatoes tasted sweeter and were sometimes more desired. (This information is based on personal communication from R. Werge. Still today, some CIP scientists have a slightly different version of the story. I suspect this is inevitable in interdisciplinary research. Farmers, no doubt, have yet another version.)

Werge, wearing his *campesinista* hat, questioned technologists' accusation that farmers' practices were "poor." He asked in what respect they were

"poor": in relation to the USA, the experiment station, the coast of Peru, or where? According to Werge, the farmers claimed they had "problems," but different ones than scientists had imagined. The problem as perceived by farmers was not with their traditional storage technology per se but with "improved varieties" that were replacing native varieties in the region. Farmers claimed that, with new varieties, they were having difficulty keeping seed tubers from harvest to the next planting (Werge 1980:15–16). They complained that the improved varieties produced long sprouts that had to be pulled off before the tubers could be planted. This, to farmers, was labour and time costly. As a result of this research, the team focused its attention on the idea that a new method of storing seed potatoes of hybrid varieties would improve production. Although on-station, basic research on potatoes for consumption continued, no clear technological problem for local on-farm testing was defined.

As early as 1972, CIP had been experimenting with a technique already known to farmers in some developing countries: natural, diffuse light reduces sprout elongation (Dinkel 1963; Tupac Yupanqui 1978). However, whether the principle could be widely used in storing seed tubers under farm conditions was not clear.

On the experiment station, research verified that indirect light reduced sprout elongation and improved overall seed quality under Andean conditions. The design of experiment station stores, however, was still based on the technologists' point of view. The question remained whether the storage design was relevant to farm conditions and acceptable to farmers. This question could only be answered through continued ethnographic research and on-farm trials with farmers' acting as advisers. The an-



Potatoes stored in diffused light had much shorter sprouts than did those stored in the dark.

thropologist, interested in the cultural uses of farmhouses and buildings, was concerned with how the new diffused-light principle might fit. A storage facility separate from the house did not seem realistic because of the lack of security and convenience. Nor did it seem possible to introduce diffused light into the dark rooms traditionally used as storage areas.

Diffused light produces greening in potatoes and renders them unsatisfactory for food. Many small Andean farmers prefer to store potatoes in the dark, even those to be used later for seed, in case they need to consume the potatoes or to market them. How to convince farmers to store seed potatoes in diffused light, given their risk-averting strategy of storing all potatoes in darkness, had not yet been resolved.

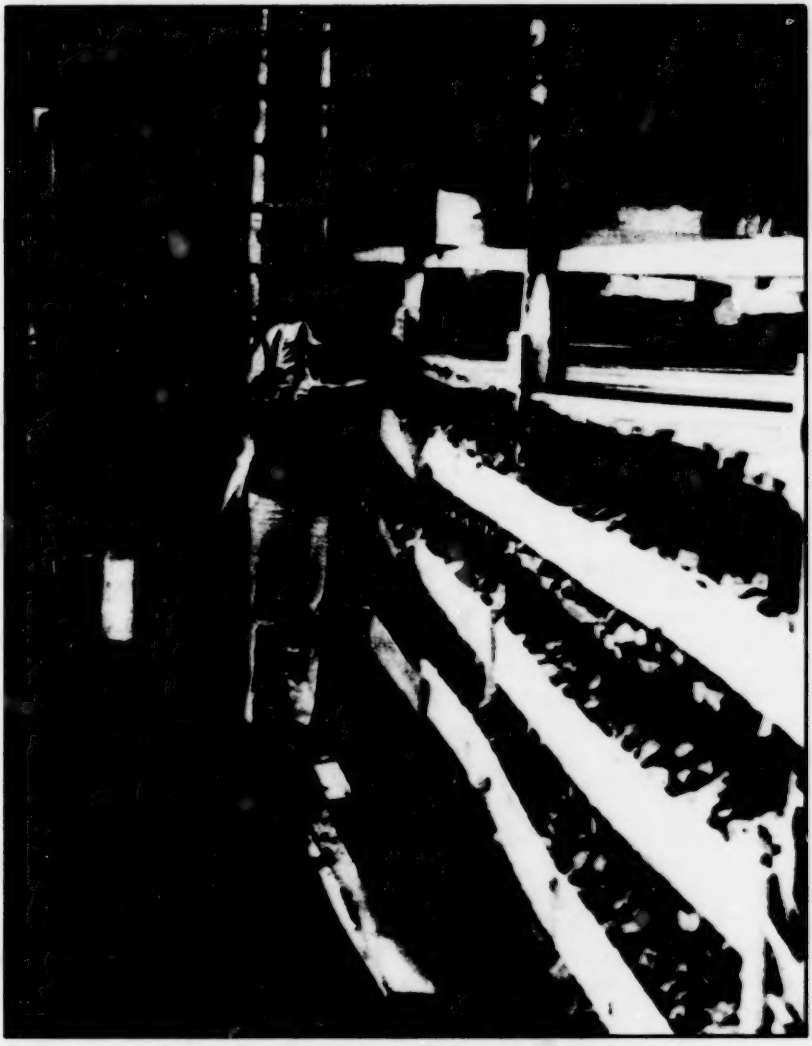
With the socioeconomic considerations in mind, CIP staff inspected farmhouses and talked over the problem with farmer cooperators. Many Andean houses have a veranda with a roof that lets in indirect light. The team decided to set up seed trays (similar to open vegetables crates) used on the experiment station in the houses of cooperating farmers. The trays were stacked up in the corridor area where diffused light, as opposed to direct sunlight, enters.

These on-farm experiments yielded the same scientific results as on the experiment station. Upon seeing that diffused-light storage reduces sprout elongation, farmers expressed interest but were still concerned about the cost of seed trays. In response to this, the team built simple collapsible shelves from local timber and used them in a second series of on-farm trials. The results were again positive, and, this time, farmers were able to relate more closely to the rustic design of the stores. Throughout, scientists were learning more and more about both the technical and the socioeconomic aspects of storage and the proposed new technology.

Still, by 1979, 3 years after the interdisciplinary team began research, no evidence was available that farmers would accept the technology. The validity of the team's research approach still depended on whether farmers were willing to use the diffused-light principle at their own expense and time. By this point, however, the principle of using diffused light in rustic stores had been introduced through CIP training courses to potato workers in 21 countries of Asia, Africa, and Latin America.

The first tangible payoff of the team's efforts did not come in Peru, but in the Philippines (Rhoades et al. 1983). As a result of a visit by Dr Robert Booth of the postharvest team, farmers in the main potato-producing region decided to finance a demonstration of diffused-light storage. This store was followed by five more demonstration stores built by the Philippine National Potato Program and backstopped by the local extension service.

In the Philippine case, farmers were clearly not "adopting" the demonstration model but rather *adapting the principle of diffused light to their cultural circumstances and needs*. Regional-development workers expected that farmers would copy the demonstration stores and had difficulty believing that the farmers would use ingenious methods to adapt the idea to their conditions. Follow-up in the adoption areas, however, demonstrated clearly that a "technology" as a unique, physical "package" was not being accepted. What, in fact, was being accepted was the principle of diffused light.



Large diffused-light store under a veranda in the Andes.

Worldwide, this principle has been translated into an amazing array of farmers' versions of potato stores, each with a particular cultural flavour. Wherever the idea was introduced through demonstration models, farmers quickly began to experiment on their own. Later, as adoption spread in Peru, farmers simply placed a few potatoes under the veranda, an experiment that involved virtually no inputs. Others, either as a first stage adoption or elaboration of the spreading trial, constructed a raised platform, under the veranda, a modification that allowed for better ventilation. Other farmers built simple structures, but few were exact copies of demonstration stores. In some cases, associations or farmers' cooperatives built stores with capacities

up to 100 t, many times larger than the rustic demonstration models. To date, a documented 1500 stores have been built by farmers in developing countries.

As a result of farmer evaluations, the postharvest team encouraged national programs to establish demonstration stores illustrating different ways that the principle might be adapted. Farmers did not automatically accept the relevance of the principle, especially if the national program had constructed a relatively costly demonstration model. Sometimes, extension workers became frustrated when farmers did not precisely copy their design.

Thus, much was to be gleaned from monitoring — not only what farmers do and need but also how to improve the technology and avoid production contexts where it might be inappropriate. For example, in areas where farmers want to break dormancy rapidly to meet a planting date, the diffused-light principle offers few advantages. Understanding the decision-making behind adoption or rejection requires continued interdisciplinary research with farmers as the primary advisers.

Farmer-back-to-farmer: a model

The CIP team developed an action-, problem-, and client-oriented model that we at the centre have used in training courses (Rhoades and Booth 1982). Called by us the farmer-back-to-farmer approach, it offers some relief from what we feel are the fruitless dialogues between *campesinistas* and *tecnicistas*.

The CIP postharvest team openly admits that adaptive research potentially involves at least three distinct perceptions of reality and three sets of motivations: social scientists', technologists', and farmers'. Extensionists might be added as a fourth. These separate views of reality can be considered true in and of themselves and are based on the individual's relationship to the situation at hand. Technologists are under strong pressure by donors, administrators, and colleagues to produce a better technology that works and is adopted by farmers or consumers. Social scientists are faced with a marginal human or cultural brokers' role: articulating their understanding of the farmers' situation to colleagues from the biological sciences. Then, to complete the triangle is the farmer, the one facing the problem but who does not receive a guaranteed monthly salary to "solve farmers' problems." The farm family must live by the consequences of its decisions, not scientists'. Farmers live in both a technical and a social world based on agriculture; researchers simply study the worlds. And all this boils down to an undeniable fact: the researcher and farmer see the world differently.

Briefly, the basic philosophy upon which the model rests is that successful, adaptive, interdisciplinary research must begin and end with the farmer, farm household, and community. It does not posit that decisions as to what are important problems can be formulated on an experimental station or with a planning committee removed from the rural context and out of touch with farm conditions. The model subsequently involves a series of targets or goals that are logically linked by a circular and potentially recycling pattern of four basic activities — diagnosing problems, identifying solutions, testing and adapting the technologies, incorporating farmers' evaluations

(Hildebrand 1978; Harwood 1979:38–40). Research must come full circle from problem identification to farmer acceptance or rejection. Research, thus, is client- and problem-oriented. Research, extension, and transfer are seen as parallel and ongoing, not sequential, disjointed activities.

Diagnosing problems

The first activity in the farmer-back-to-farmer model is an understanding and learning stage. It is similar to the diagnosis stage outlined in farming-systems research, although relatively more emphasis is placed on what anthropologists call the "emic" perspective — that is, putting oneself as much as possible into the farmers' shoes to understand how they view the problem in both technical and sociocultural terms. Thus, this stage does not simply involve administering a questionnaire wherein scientists decide the relevant questions and farmers struggle to fill in the blanks. According to the farmer-back-to-farmer approach, informal surveys or formal questionnaires are not the only early diagnostic tools. Other techniques include on-farm experiments, farmer field days, farmer-advisory boards, participant observation, scientists' working hand to hand with farmers in their fields in exchange for information. The method used will vary, depending on local transportation, time, size of region, and the scientists' knowledge of local conditions and populations.

The diagnostic, or understanding, stage should include farmers, social scientists, and biological scientists, each using their own skills to interpret a problem area. The farmer-back-to-farmer approach does not encompass specific methods for determining a ranking of constraints to, or priorities for, agricultural policy at local or national levels but illustrates guidelines for effective design, generation, and spread of appropriate technology. Building upon, rather than replacing, traditional practices is the route to successful problem-solving.

In the model, farmers, because of their long-term practical experience with their land, mix of crops, climate and local socioeconomic conditions, assume the status of experts in their own right and are equal members of the problem-solving team. In this beginning stage, biological scientists will naturally focus largely on technical problems. Social scientists, bound by their own selective perception, will focus on another set of phenomena: ecology, marketing, price conditions, credit restraints, or their interpretation of what farmers believe. The challenge is to weld these different perceptions into a common framework for action.

Seeking solutions

Once the problem is generally identified and the team shares some common ground, the search for solutions is the next, but perhaps most difficult, stage. Despite public pronouncements by *tecnicistas* that a vast pool of technology is ready to be transferred to farmers, the process is not so simple. In the search for solutions, a constant on-the-spot exchange is necessary between farmers and those who test hypotheses about potential technologies on the research station. This interchange should continue throughout the selection stage. Compromises, changes, reversal of direction, or even termination of projects may be appropriate (but difficult) at this stage.

The purpose of linking on-station and farm-level team research is to arrive at a definition of potential solutions, and a portion of the farmers' problems always remains undefined. Proposed technologies are rarely solutions at this early stage because farm problems are immensely complex, interrelated, and constantly changing.

Testing and adapting the technologies

Once a potential solution or set of solutions is defined, the team — including extension workers if possible — should proceed to a testing and adapting activity. The objective now is to fit, with the farmer acting as adviser, the technology to local conditions. Generally, testing and adaptation occurs first on the experiment station followed by on-farm trials. Nevertheless, in the farmer-back-to-farmer organization of research, even during the transfer stage, the flow of information is circular between the field and the experiment station. The technology should pass through an agronomic or technical test, an economic test, and sociocultural suitability tests. The tests result in constant modification of the testing methods and the technology. CIP's storage team, for example, began by building costly seed stores on the experiment station, but data from farmers oriented the team progressively toward less-expensive designs.

During on-farm testing, the potential solution or solutions should be compared with traditional methods. This comparison can still be considered as part of the understanding stage, for there are often factors in the farming system yet unrealized by scientists and even farmers. The testing and adaptation stage may need to be recycled several times before a technology emerges that is worthy of demonstration and independent evaluation by farmers. Also, sometimes, one will find that the traditional method cannot be improved.

On-farm research is not much value if farmers do not consider themselves part of it and make straightforward suggestions on the technology being tested. Involving farmers to this extent is not easy in parts of the world where farmers are outwardly submissive to urban-based research scientists. Building rapport is the best way to gain farmer cooperation, and this requires that scientists spend much time in the field.

Farmer evaluation: the crucial stage

In the agricultural-development business, technologies are typically released and forgotten. Storages are built, irrigation canals constructed, livestock or crop varieties introduced and are rarely seen again by the innovators who, by then, have terminated their contracts and gone on to other assignments. Follow-up is rare, perhaps because the innovators assume the job is accomplished — that it is the responsibility now of a national program — or they fear that the real results won't be palatable. In contrast, follow-up is the crucial final link in the farmer-back-to-farmer model. Data must be collected on the reception of the technology by farmers, the ultimate judges as to the appropriateness of a technology. Until this stage, all scientific evaluations remain at the level of hypothesis. Unless the circle is completed, unless research results reach the farmer, prior efforts can be considered fruitless and research findings will be shelved to gather dust. And, if the technology is rejected by farmers, research should be repeated to determine reasons and seek ways to overcome the problems. One may only

have to return to the adapting stage, but, if the technology is totally rejected, a new slice of the "farmer problem" needs to be taken.

The final stage involves the independent evaluation and use by farmers of the technology under their conditions, resources, and management. At this stage, scientists must not only determine acceptability but understand how farmers continue to adapt and modify the technology. Likewise, researchers must monitor the impact of accepted technology to ensure that it does not produce detrimental side effects.

Commentary

W.A. Stoop: The contributions by Blackie and Hildebrand both stress the value of rapid reconnaissance surveys — *sondeos* — as a first step toward identifying major constraints in the farmers' production system. I suggest that the *sondeo* be repeated also in neighbouring areas to place the farming system of the target area in a wider context so that researchers can anticipate how the system will change under different environments. Along with being descriptive, the *sondeo* should attempt to explain the current systems: Why do south Malian farmers intercrop maize with millet? Or why do farmers grow five different varieties of sorghum?

The effectiveness of the *sondeo*, however, depends greatly on the past experience, skills, and personality of the scientists: how carefully they verify information with field observations; how effectively they can view the world from the farmers' perspective; and, on this basis, how objectively they can judge their proposed technology. Unfortunately, many biophysical scientists focus only on increased production; they disregard, or view as secondary, the farmers' goals of spreading risk and labour resources effectively. They often also ignore the consumption preferences of the local population.

Although the rapid reconnaissance survey falls short of the ideal — comprehensive data collection and analysis — it offers an important tool to national programs that often have serious financial and personnel limitations. It is a simple and relatively inexpensive method to conduct farmer–researcher dialogue, which must be complemented, however, by on-farm experiments. National programs generally cannot afford in-depth surveys, long-term studies of farmers' behaviour, or high precision in experiments. These methods should be the realm of more fundamentally oriented research programs.

My experience has been that a useful farmer–researcher dialogue can be developed through nonreplicated, systematic observation trials in farmers' fields. The results provide a basis for examining broad concepts before more farmers are asked to participate in tests. Experience has shown that farmers will adopt and fine-tune techniques that actually alleviate their constraints or provide additional production options. For example, in 1980, ICRISAT tested an introduced sorghum variety E 35-1 in various villages in Upper Volta. Though the net gain over the local sorghum across many sites

was minimal, farmers observed the much greater response of E 35-1 to fertile soil. Consequently, they adopted the variety in the next season for use on small, highly fertile plots, near their houses. Similarly, in 1982, the south Mali project tried to introduce a cowpea forage intercrop in maize. The test result was disappointing because the cowpea was planted too late and suffered from competition with maize. However, in the next year, the farmer, recognizing the usefulness of the concept, interplanted the entire maize field with cowpea 2.5 weeks (instead of 5 weeks) after the maize with good results. In these examples, experimental precision (i.e., replication) was only a concern at the experiment station.

The fine-tuning of technologies by farmers is particularly relevant under high-risk environments (e.g., the semi-arid tropics), as farmers continuously modify their production strategies in response to the season. Elsewhere, under more predictable conditions, farmers make most production decisions before the start of the season, allowing a greater degree of standardization of technologies.

Many papers in this volume have centred on agronomic interventions on a plot or, at most, a field, while often using experiment-station methodologies to test differences between treatments. In contrast, Kleene's paper challenges researchers to deal with a whole set of topics, like livestock, integration between livestock and agriculture, and erosion and to view these at the levels of households, villages, or even watersheds. For these levels, appropriate methods of experimentation and evaluation still need to be developed. Most of the current interventions for the south Mali project are purely development oriented, because no comparisons with alternative treatments are made.

Finally, Hildebrand stressed the involvement of policymakers and infrastructure managers who, in Latin America, play an important role in enabling the introduction of improved technologies. One wonders whether the absence of similarly strong institutions in the West African setting is after all at the base of the agricultural-development problems.

Mulugetta Mekuria: The crucial role that farming-systems research plays in agricultural development is to make research more problem-oriented. Shaner et al. (1982) summarized farming-systems research as:

- Farmer-based, for it seeks an understanding of farmers' conditions and it aims to integrate farmers into research and evaluation;
- Problem-solving, for it seeks researchable problems and opportunities for improving existing systems;
- Comprehensive, for it deals with the whole farm or production system;
- Interdisciplinary, for it involves scientists and extensionists from different disciplines as well as farmers;
- Complementary, for it draws on, and feeds back to, the different disciplines for commodity-based research;
- Iterative and dynamic, for it follows a cyclic pattern of research and testing; and
- Socially responsible, for it is intended to serve the public interest.

With these features in mind, I have reviewed the papers by Prakah-Asante et al., Abalu et al., and Matlon. They emphasize that farm tests provide essential information about the endogenous and exogenous factors

contributing to low productivity under farmers' conditions. The researcher-managed trials of relatively large numbers of treatments and farmer-managed trials provide different, but crucial, input into the design of appropriate techniques. I agree with the emphasis on farm tests, but I think that the papers have overlooked the involvement of the extension service, even though WARDA has as one of its objectives to devise a strategy for extension education. Like the farmers, extension staff should be involved from the early stages of problem identification to technology evaluation.

As researchers, we have to be aware that the major link between the researcher and the farmer is the extension workers because they are dealing with a much larger audience than are the researchers. If adequately involved in technology evaluation, they can offer practical insights from their experience. Their involvement ensures feedback not possible from farmers. Farming-systems teams should monitor the spread and evaluate the performance of innovations.

Having said this, I would like to raise specific questions that emanate from the papers:

- Is it possible to standardize the methods, design, analyses, plot size, etc. in farm tests, or must one come up with specifics for each system? I believe that many of these items can be standardized to exploit the homogeneity within peasant agriculture.
- What methods will consider all the variables in the complex systems of production common in subsistence agriculture? WARDA studies rice; ICRISAT, sorghum, groundnut, millet; but these form only a small part of the picture, which includes many crops, livestock, etc.
- If the farmer is truly a partner in research, why give guarantees and subsidies when the risk in agriculture is evident?
- What are the indigenous methods of experimenting that would be relevant for further adoption in the design of on-farm tests? Farmers do experiment. Some follow staggered planting to distribute the risk brought about by erratic rainfall. Others plant mixed varieties of crops to control diseases and pests, among other reasons; they plant large numbers of seeds to reduce weed competition or to offset poor germination.
- What are the implications of problems (bias, high variances, etc.), cited by Mardon, in on-farm tests? What are the prospects for early improvements, and how much feedback is needed?

I hope that some of these questions can be addressed in future so that a better picture will emerge, clarifying the tests and evaluation criteria for on-farm testing, the role and degree of farmers' involvement in evaluation as opposed to the scientists' traditional (reductionist) approach to agricultural research.

David Nygaard: I am a little dismayed and more than a little frustrated that we, as researchers, are spending too much time — often in confusion — talking about differences: differences in projects, differences in approaches, and differences in disciplines. We are, therefore, spending too little time talking about points of agreement.

We do agree that farming-systems research requires multidisciplinary teams and the involvement of the farmer. I believe that we agree on a few

additional principles. Farming-systems research is a process to develop new technologies that Norman (1980) characterizes as having four stages: diagnosing, experimenting or designing, testing, and diffusing. It is dynamic and iterative; researchers work at several stages simultaneously and, more importantly, continuously because there is no beginning and the effort is ongoing. Although the divisions between the stages are not distinct, I distinguish between the designing and the testing stages on the basis of farmers' involvement: scientist-managed, jointly managed, and farmer-managed trials. Researcher-managed trials, whether they are at the research station or on farmers' fields, fall into the second stage, designing, whereas the other two are steps in the third stage, testing. Matlon breaks these trials into six groups; his is just a finer division and is compatible with mine.

The differentiation is worthwhile because it serves as a reminder that:

- First, at one stage, farming-systems research, just like other types of research, encourages creative but risky investigation. Design work, even on farmers' fields, can, and indeed sometimes will, fail. The risk is acceptable because of the potential payoffs. For example, at the International Center for Agricultural Research in the Dry Areas (ICARDA), 70–80% of the budget for farming-systems research is for the design stage.
- Second, stages one to three are research and, as such, are provided with more flexibility when done on farmers' fields than when done on research stations.

This perspective will answer, to a large degree, concerns that have been expressed about mistakes on farmers' fields, risky tests, who pays for what, etc. These are concerns at the demonstration stage not the research stage. I believe one of the unique contributions of farming-systems research to agricultural research is to move research to farmers' fields.

The dynamic nature of farming-systems research provides investigators with tremendous flexibility and allows one to diagnose and test at the same time. On-farm trials help researchers to diagnose farmers' problems. In our research at ICARDA, we found improved communication with, and better information from, farmers once they became actively involved in the research. Problems still remain, and I think Matlon nicely summarizes these in his conclusions. Nevertheless, I think all the authors would agree that the value of on-farm tests is that they improve our understanding of farmers' circumstances.

Visualizing farming-systems research by stages is useful because it clarifies what researchers are trying to do, why, and where. That is, it clarifies objectives and, more importantly, provides a measure of productivity. I agree with Binswanger's comments on the importance of clearly stating the purposes of our research, and I believe they should be repeated: researchers are wasting too much time comparing apples and bananas under the false assumption that they are talking about the same thing.

Many of the concerns mentioned in the papers by Prakah-Asante et al. and Abalu et al., e.g., plot size, number of trials, etc., depend on the objectives and the stage of the research. Once the objectives are clear, these questions will answer themselves.

The sequence of events is crucial. For example, I was surprised to see in

Matlon's paper that, in farmer-managed tests, he expected to determine interactions among inputs, even though he had no replicated plots. That, to me, is a task for researcher-managed plots where one can control the factors. I suggest that the lack of control on farmer-managed plots means that other types of analysis are necessary for farmer involvement in evaluation.

Although many papers have dealt with farmer involvement in on-farm tests, I am disappointed to find that they do not suggest concrete ways to increase or improve farmer involvement. At ICARDA, we have accepted:

- That the farmer is an equal partner and member of the farming-systems research team. The team is not talking to the farmer but, along with the farmer, is making decisions with respect to the allocation of research resources. As we have gained experience, we have recognized how valuable the farmers' contribution is. Therefore, any way to increase this active participation should be encouraged. This is one reason that research should commence early in the farming-systems research process in on-farm tests.
- That the team must define objectives for each task, including a measure of accountability. The methods depend on the objectives that the team has set. There are, for example, different objectives in the two survey approaches McIntire compared, and there is a danger in assuming they are substitutes. The question "which method should I use?" cannot be answered until the objectives are defined. We use several types of surveys at ICARDA, depending on the task at hand.
- That timeliness is the key to improving communication between team members. All team members should share information quickly

Livestock are essential components in farming systems and need to be part of research design.

because, for example, an agronomist may not be able to wait for full economic analysis of agronomic experimentation. At ICARDA, in on-farm tests of barley, we circulated, within 24 hours, writeups of interviews with the farmers. We received more comments from biological scientists about these writeups than any other single thing we have written.

One of the most interesting cases of creative communication techniques that I have seen was in Turkey. A videotape was made in a coffee shop in a village where the farmers were discussing the problems of adopting a technological package recommended by the government. The tape was shown to high officials in the Ministry of Agriculture in Ankara, confronting them with all the problems — late delivery of inputs, high costs for transport, lack of credit — and prompting them to address the bottlenecks.

On-farm tests with animals are just starting at ICARDA but are very important. Involving farmers in these tests is much more complicated than involving them in tests of crops. I am disappointed not to find, in this volume, any paper on animal research on farmers' fields. The papers do give prescriptions for on-farm tests with crops and do a good job in this respect. In my opinion, what is now needed is case studies that show these prescriptions work, that show farming-systems research offers results that would not be likely to emerge from other approaches. The results must be measured in terms of increased agricultural production in the region.

L.K. Fussell: Many of the papers in this volume give "lip service" to increased farmer participation. Or perhaps the goal is better described as wishful thinking. The use of phrases like "technological packages" implies a largely finished product that needs only fine-tuning by the farmer for adoption. The farmer has only been brought into the late stages of design and evaluation. How relevant can a technical package be if the farmer does not have input before this stage?

I believe that early farmer participation can add much to technology development. The farmer should be involved in all stages, not only the diagnostic and evaluation stages, but the design and development stages. This then implies that all research disciplines involved in technology development should have dealt with farmers if the technology is going to end up in farmers' fields.

Breeders, entomologists, plant pathologists, and agronomists cannot leave the work to anthropologists, economists, and maybe a farming-systems agronomist, as represented by the contributions to this volume.

As an agronomist, I have gained enormous insight and understanding of the farmers' environment, objectives, and constraints, through technological research that began on farmers' fields at the same time as on the research station. The early feedback from the farmer (from my experience in Niger) allows a reorientation of technology design and development in keeping with the farmers' objectives and personal tastes.

Many papers in this volume compartmentalize farming-systems research into, basically, three stages — diagnosis, technological design and development, and evaluation with farmers' input before final adoption. This compartmentalization as found, for example, in Prakah-Asante et al.,

confines technological development to the research stages by the researcher. Thus, when interaction takes place after the diagnostic stage, the researchers are already committed to their prescription — the technology that has been designed and largely developed. The farmer–researcher dialogue must be established early and continued right through design, development, and evaluation of technology. The papers indicated that research institutes are heading for, though fall short of, a continuum of research between the research station and the farmers' fields. This continuum involves the farmers from the beginning in development of technology that they are going to use.

Some researchers talk about "upstream" and "downstream" approaches to farming-systems research and farmer participation in the development of new technology. I propose that the *pond approach* is what is needed. This approach implies that the social, technological, farming, and systems researchers as well as the farmers can engage in a free flow of dialogue in evaluating new technology that meets the farmers' goals. The farmer participates in every stage of technology development.

The papers in this volume indicate that farming-systems research is largely at a transitional stage of farmer participation. Previously, technological packages were designed and developed within the research environment where the farmer had little, if no, input. Technological packages were presented to development agencies and national programs to extend to farmers as finished products. Now the finished products or technological packages are being evaluated on farmers' fields by the researcher and by the farmer. But researchers still have not reached fully the continuum of research between the research station and the farmers — the pond approach to farming-systems research. In fact, there is a tendency to fall back to old ways of forcing technologies on the farmer (e.g., using the results of a diagnostic survey as a basis to ensure widespread adoption). I think the papers in this publication clearly show that some people are not distinguishing between the goals of farming-systems research and development and those of extension.

Y. Bigot: I find myself both reassured and concerned by the papers in this publication, such as the one by Kleene. On the one hand, it is reassuring to see unity of direction emerging; on the other hand, I am concerned because questions that are basic to truly operational research remain unanswered.

The papers agree on three types of tools for promoting farmer participation. The first is the interdisciplinary survey, which makes it possible to stratify the rural environment and diagnose technological problems in that environment so that research can be organized appropriately. The second consists of technical trials that take any one of a wide variety of forms, depending on the degree of responsibility given the farmers in conducting the trials. The third type is farm counseling established for selected farmers and intended mainly to measure the many interactions involved in technological decision-making in actual farm management.

My concern is that merely identifying these tools is not enough to guarantee that the research activities function well and that the technical results can be disseminated in the rural environment. Management of the tools, many of which are costly, is not an adequate objective. To improve research practices, one must investigate the technical priorities in a given environment more thoroughly. In this way, management of the tools, input

from various disciplines, and participation by farmers can provide a set of coherent methods with respect to specific technical objectives. I feel one must replace general reflections with concrete case studies based on a list of questions, such as: What are the major technical concerns that have been identified through extensive surveys and their application in certain villages and farms? Have farmers participated in an effective way? Has it been possible to organize the vague area of feasible technical alternatives to define priorities? What consideration has been given to the general constraints, owing to which the appropriateness of technologies depends not only on the farmers but also on downstream and upstream production factors? How have efforts to resolve technical problems dealt with the difficulties and priorities previously identified? What technological concerns have already been resolved, given that a technological solution is never definitive and that it always raises new difficulties?

There is a risk that farmers will be asked to participate in refining technologies that are of questionable validity. If farmer participation is to be effective, methods used to analyze and evaluate the validity of technologies must evolve so that technical-assistance activities can be organized appropriately.

Conclusions

Roger Kirkby and Peter Matlon,
International Development Research Centre, Regional Office for Eastern and Southern Africa, Nairobi, Kenya; and International Crops Research Institute for the Semi-Arid Tropics, Ouagadougou, Upper Volta

Participation of farmers in the development of agricultural technology, although not an objective in itself, is a means of improving the chances that innovations will be useful and acceptable and of minimizing the costs and time necessary for the development of adapted technologies. Like other inputs in research, it should be planned carefully so that the program of on-farm experimentation permits and encourages the desired level of input at the right time.

This often means a departure from conventional experimental designs and procedures. Appropriate methods for surveying and analyzing peasant farming systems and for designing and evaluating technology to improve those systems are still evolving and depend partly upon what is already known about the local farmers and their systems as well as on the experience of the scientific team. For these and other reasons, the methods among programs differ, and the differences tend to mask their convergence from separate origins in biological and economic disciplines. The methods will continue to converge if the researchers can resist the temptation to coin new jargon (which blocks communication) and to advocate too vigorously an uncritical adoption by others of their procedures. The papers in this volume have rejected the terms "upstream" and "downstream" as misleading classifications of the approaches to farming-systems research.

The papers treat what, when, and how farmers can contribute to the design and development of technology, but one of the elements that is generally missing is how researchers have elicited effective participation by farmers.

What, when, and how farmers contribute

The findings are that:

- Farmers can assist actively in the analysis of their farming systems, giving insights into sources of ecological and socioeconomic variation and providing accounts of the "rules" of behaviour, including those for farming (when and how deep to plant, etc.). The methods used by researchers to obtain the information include rapid reconnaissance surveys — the *sondeo* — key informants, exploratory and in-depth interviews, and case studies. Group discussions and other techniques in which the researcher is primarily an observer warrant further attention and scrutiny.

- Farmers are a source of technology. They have developed techniques and equipment by trial and error to simplify their activities or to make them more effective. Researchers should search for such technologies and consider them for prototype testing elsewhere. Transfer of technology between developing-country farming systems with similar agroecological conditions and constraints has too often been disregarded by researchers who, instead, focus on development of new techniques or on transferring techniques used in developed countries.
- Given adequate information, farmers can help select technology worth testing, by indicating specific technical problems and prescreening technologies for feasibility.
- When on-farm tests are under way, the farmers can modify treatments or management in response to environmental fluctuations (both agroecological and socioeconomic), drawing on their stock of knowledge about local conditions.
- During and after the tests, the farmers can share the task of evaluation and thereby contribute to the design or redesign of the following season's research program.

Increasing farmer participation in experiments

The first step in optimizing involvement of farmers in on-farm experiments is to organize the tests so that they reflect the objectives, circumstances, and stages in technology development. Although experiments in which treatments and variables are carefully managed by researchers are essential during the early stages of technology design so that one can establish the technical relationships among the factors of production, farmer-managed experiments should constitute an important portion of the program. The experiments should be designed on the basis of careful consideration of the desired level of farmer involvement as well as technical and statistical precision required by the objectives of the tests. For instance, if the objective is to study the interactions between different management techniques and fertilizer treatments, the researchers could apply the fertilizer (precision necessary) to plots replicated in several farmers' fields, with farmers' managing all other aspects and researchers' recording all the activities.

There are several ways that researchers can increase farmer participation in research:

- Respect the farmers; they are a valuable source of local knowledge and experience and, ultimately, the people who determine whether a new technology is adopted. They are colleagues and members of an interdisciplinary team and must be treated in an appropriate manner. Communication and mutual trust can be encouraged by openness, respect for customs as well as constraints. (For example, researchers should arrive for meetings or field visits on time, schedule visits at times convenient to the farmers rather than during official working hours, avoid forcing farmers into meeting unnecessary costs or social obligations, such as providing meals.) They should also use language and units of measure that are meaningful to the farmers. Anthropologists, because of their skills in determining local norms, can

usually assist agricultural scientists and other researchers to find acceptable and effective ways to show respect for the farmers and their cultures. In addition, universities should be instilling in researchers of all disciplines an awareness of the contributions possible from farmers and from scientists with other specialties.

- Make use of farmers' experiences with technology; agriculture in general, and the farmers' current production patterns, practices, and varieties in particular, are products of nonformal experimentation conducted by most, if not all, farmers. This often includes their trial-and-error testing and modification of recommendations extended from formal research programs. These programs can now benefit from farmers' traditional experimentation, as farmers' can be expected to have superior local knowledge about soils, their suitability for certain cropping patterns, indicator species as measures of soil fertility, adaptive range of local and introduced varieties, etc. Researchers can quickly establish rapport by demonstrating their genuine interest in learning what farmers already know and using it in the design of research programs.
- Establish rapport as early as possible through introduction of on-farm tests; the first season of on-farm tests is planned on the basis of a workable but incomplete understanding of the area's requirements for technology. The systems approach to technology generation is iterative, and the sequence of on-farm experiments permits researchers to refine their preliminary analyses of the production system. Early experiments giving full weight to farmers as evaluators can help establish the active, creative role farmers should play in subsequent stages.
- Ensure farmers understand the objectives of the experiments; farmers, as well as researchers, need to distinguish between an on-farm experiment and a demonstration. Although on-farm tests may demonstrate effective techniques, they are primarily experiments to develop, refine, or verify technology that is not yet proved for farmers' circumstances. Farmers who understand the research objectives are likely to be more honest in their assessment of the technology and less disappointed and critical of unfavourable results than are those who view the exercise as a demonstration. Researchers need to caution farmers that the technology is not yet proved and that their assistance in evaluating it would be appreciated.
- Include technology designed to meet farmers' perceived problems; after the research needs of an area have been analyzed, technology must be designed to solve the problems and to improve the exploitation of resources. Farmers are more likely to become involved quickly in a program that is oriented toward solving problems with which they are concerned (e.g., a crop pest causing visible damage) than in one focused on potentials with which they are unaware (e.g., fertilizer-responsive varieties). Once farmers appreciate the benefits accruing from the program, more ambitious approaches may be taken. The approach depends on the information available about alternative technologies for the area and the farming economy (subsistence or cash orientation). This is the reason that approaches to farming-systems research in Africa differ from those in Asia.

- Select farmer cooperators according to experiment objectives; farmers' circumstances and needs for research differ even within one agroecological zone. Stratifying the farmers on the basis of this variation should be a first step in designing a program of experiments. By focusing on the variation, researchers can discover the farmers whose interest in the program is likely to be high. Allowing the farmers to choose among several types of technology that have been selected for development or testing is a way to increase their interest, enhance their understanding of objectives, and acquaint them with what others in the community may be involved in. It should also lead to more valid evaluations.
- Allow farmers to modify experiments; the program of on-farm experiments is designed to test technology for appropriateness to a set of circumstances common to many farmers, although only a few individuals can be selected for active cooperation in testing. Maintaining a degree of consistency over tests replicated with several farmers is, thus, important to later interpretation. However, the advantage of farmer-managed tests is that they provide researchers with some idea of how a technology performs when farmers use it. The way to exploit this advantage is to encourage individual initiatives in selection and application of treatments, ensuring that only the essential components are replicated. For example, farmers could add several local varieties to a variety trial without impeding the analysis of results; similarly, farmers should be allowed flexibility in management, especially in response to unforeseen circumstances, such as drought, pest attack, or shortage of labour for weeding. The flexibility increases the observations, interviews, and recording that must be done by the researchers but maximizes the advantage of on-farm tests. The use of large samples — plots and farmers — is essential for valid comparisons of on-farm tests in which farmers choose management strategies and allows results from different fields to be regrouped for analysis.
- Reach agreement with cooperating farmers about who will contribute what to the tests; maintaining the confidence of farmers depends partly on a clear initial understanding of responsibilities and a just interpretation of the commitments when unexpected events occur, such as crop failure. Honesty and openness on the part of the researchers are a key to successful discussions with farmers, but there is no consensus on how much of the costs and risks associated with experimental treatments should be absorbed by the farmers. Many people advocate programs that provide experimental inputs free but expect farmers to provide all other inputs; others argue that provision of treatment inputs on large plots unnecessarily biases the assessment provided by the farmers because it tends to create dependency upon continued collaboration with the researchers.
- Organize on-farm experiments in a manner similar to traditional experimentation; farmers carry out their own tests of new technology imported from neighbours or introduced by extension agents before adopting or rejecting it. Although customarily of interest only to anthropologists, how farmers conduct their tests is vital information for researchers who wish to involve farmers closely in technology testing. For example, does the farmer use a particular pattern or

number of rows when testing new varieties? How can the experiment be designed to be compatible with the farmer's practice? And how many treatments can be compared before the experiment becomes too complex to maintain the farmer's interest?

- Encourage farmers to think of the experiments as their own; farmers will treat experiments as being of concern only to researchers unless they are given good reason to identify with the tests. If they view the experiments as their own rather than as fields on loan to the researchers, and feel that the technology, if proven useful, will be available to them, they are likely to use management practices that they trust and to assess tests carefully. Information from the tests will be valid for other farmers in the area and will not be lost to the researcher even if he or she is not present during harvest.

The future

The potential for coopting farmers' traditional experimentation to improve formal programs of technology generation, particularly to save analytical costs and time in conducting evaluation of potential innovations, is not yet clearly understood. Systematic study of traditional methods by technically trained scientists working together with social scientists in a small sample of farming systems would be useful: researchers need to know how farmers look at and evaluate new technology, particularly in subsistence agriculture. Researchers who are truly interested in improving the farmers' production must be willing to explore the social organization, attitudes, and production practices of the farmers, and agricultural scientists must be able at some stage not only to relinquish control of the testing but also to impart a sense of proprietorship and control to the farmers. Superimposing an experiment to test crop technology (varieties or fertilizer levels, for example) upon the farmers' normal crop, in preference to sowing the experiment on a separate day and in a separate site, is one possibility, and it requires particularly good organization and preparedness on the part of the research team, for which additional training may be needed.

Probably no one has yet exploited fully the potential for involving small farmers in developing countries in the process of generating new technology. One group of formal research institutes that has not had a voice in this volume is nongovernment organizations. NGOs tend to work closely with farmers in programs that are often based on twin concepts of operational research and extension. A cross-fertilization of approaches and procedures between such groups and other research institutions could be particularly beneficial.

Another area that has been inadequately considered is the potential for improving cost-effectiveness of research through use of farmer–farmer interaction and assistance to farmers in conducting more intensive experiments of their own. Farmers learn about technology from one another and even hire one another as technical consultants. For example, Tanzanian researchers at the University of Dar es Salaam have recently coordinated farmer–farmer exchange by encouraging a group of farmers to introduce a well-adapted traditional technology to a different tribe in a new area having similar ecology and assist both the new group and the researchers in

installing a formal experiment to assess its performance. Similar approaches are now in use in one region of Upper Volta where groups of farmers regularly exchange visits to observe how standard soil-conservation principles have been adapted by farmers from different villages to fit with their local needs and resources.

There is, thus, still much to be done, but a start has been made, and more precise procedures and their limitations can be expected with experience, provided that technical scientists see active participation by farmers as an important tool and that they allow sufficient time to elicit it.

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Participants

Aithnard, Tonyawa Director, Direction de la recherche agronomique, B.P. 341, Lomé, Togo.

Balcet, Jean-Claude Agricultural economist, International Bank for Reconstruction and Development, 1818 H Street NW, Washington, D.C. 20433, USA.

Batabe, Cora Mathias Economist, Autorité des aménagements des valées des Voltas, B.P. 524, Ouagadougou, Upper Volta.

Belem, Célestin Agroeconomist, Institut voltaïque de recherche agronomique et zoologique, B.P. 574, Ouagadougou, Upper Volta.

Benoit-Cattin, Michel Agricultural economist, Institut de recherches agronomiques tropicales et des cultures vivrières, B.P. 5035, 34032 Montpellier Cedex, France.

Berger, Michel Agronomist, Institut de recherches du coton et des textiles exotiques, B.P. 208, Bobo-Dioulasso, Upper Volta.

Bigot, Yves Agricultural economist, Institut de recherches agronomiques tropicales et des cultures vivrières, Groupement d'études et de recherches pour le développement de l'agronomie tropicale, B.P. 5035, 34032 Montpellier Cedex, France.

Billaz, René Scientific director, Groupement d'études et de recherches pour le développement de l'agronomie tropicale, B.P. 5035, 34032 Montpellier Cedex, France.

Binswanger, Hans P. Agricultural economist, International Bank for Reconstruction and Development, 1818 H Street NW, Washington, D.C. 20433, USA.

Blackie, Malcolm Dean, Faculty of Agriculture, University of Zimbabwe, P.O. Box MP167, Mount Pleasant, Harare, Zimbabwe.

Bouwen, Inge Virologist, Food and Agriculture Organization of the United Nations, Permanent Interstate Committee for Drought Control in the Sahel, Projet Lutte Intégrée, B.P. 575, Ouagadougou, Upper Volta.

Braud, Michel Agronomist, Institut de recherches du coton et des textiles exotiques, 42, rue Scheffer, 75116 Paris, France.

Broekhuyse Agroanthropologist, Royal Tropical Institute, Mauritskade 63, 1092 AD Amsterdam, Netherlands.

Cantrell, Ronald Agronomist, Farming Systems Unit (Purdue University)/Semi-Arid Food Grains Research and Development Project, B.P. 1783, Ouagadougou, Upper Volta.

Chantereau, Jacques Breeder, Institut de recherches agronomiques tropicales et des cultures vivrières, B.P. 596, Ouagadougou, Upper Volta.

DeWalt, Billie R. Anthropologist, Department of Anthropology, University of Kentucky, Lexington, Kentucky 40506, USA.

Diallo, Souleymane Agricultural economist, Institut panafricain pour le développement/Région Afrique de l'Ouest Sahel, B.P. 1756, Ouagadougou, Upper Volta.

Djegui, Narcisse Agronomic engineer, Département de la recherche agronomique, Station de recherche sur les cultures vivrières de Niaouli, Via Attogon, Benin.

Dugue, Patrick Agronomist, Institut de recherches agronomiques tropicales et des cultures vivrières, B.P. 633, Ouagadougou, Upper Volta.

Eponou, Thomas Agricultural economist, Centre ivoirien de recherches économiques et sociales, B.P. 1295, Abidjan 08, Ivory Coast.

Fresco, Louise Agronomist, Department of Agricultural Extension, Agricultural University, Wageningen, Hollandseweeg I, Wageningen, Holland.

Fussell, Les Agronomist, International Crops Research Institute for the Semi-Arid Tropics, Sahelian Center, B.P. 12404, Niamey, Niger.

Ghuildyal, B.P. Assistant representative, Ford Foundation, New Delhi, 55 Lodi Estate, New Delhi 110003, India.

Gladwin, C.H. Assistant professor, Food and Resource Economics Department, University of Florida, G155 McCarty Hall, Gainesville, Florida 32611, USA.

Glover, David Program officer, Economics, Social Sciences Division, International Development Research Centre, P.O. Box 8500, Ottawa, Canada K1G 3H9.

Gomez, A. Lillyam Entomologist, Food and Agriculture Organization of the United Nations, Permanent Interstate Committee for Drought Control in the Sahel, Projet Lutte Integrée, B.P. 575, Ouagadougou, Upper Volta.

Hildebrand, Peter E. Professor, Food and Resource Economics Department, University of Florida, McCarty Hall, Gainesville, Florida 32611, USA.

Hirvonen, Maarit Program officer, United Nations Development Programme, B.P. 575, Ouagadougou, Upper Volta.

Kabore, D. Research assistant, International Crops Research Institute for the Semi-Arid Tropics, B.P. 4881, Ouagadougou, Upper Volta.

Kabore, Moussa Accelerated crops production officer, Semi-Arid Food Grains Research and Development Project, B.P. 1783, Ouagadougou, Upper Volta.

King, J. David Associate director, Economics and Rural Modernization, Social Sciences Division, International Development Research Centre, P.O. Box 8500, Ottawa, Canada K1G 3H9.

Kirkby, Roger A. Agricultural program officer, Agriculture, Food and Nutrition Sciences Division, International Development Research Centre, P.O. Box 62084, Nairobi, Kenya.

Kleene, Paul Social economist, Institut économie rurale, Mali/Institut royal des régions tropicales, Pays-Bas, B.P. 186, Sikasso, Mali.

Lang, Mahlon Economist, Farming Systems Unit (Purdue University)/Semi-Arid Food Grains Research and Development Project, B.P. 1783, Ouagadougou, Upper Volta.

Lippold, Paul C. Chief, Special Initiatives Section, Africa Bureau, Agency for International Development, Washington, D.C., USA.

Maharoux, Alain Geographer, Institut panafricain pour le développement/Région Afrique de l'Ouest Sahel, B.P. 1756, Ouagadougou, Upper Volta.

Matlon, Peter J. Principal economist, International Crops Research Institute for the Semi-Arid Tropics, B.P. 4881, Ouagadougou, Upper Volta.

McCorkle, Constance M. Center for Research on Economic Development, University of Michigan, B.P. 35, Ouagadougou, Upper Volta.

McIntire, John Principal economist, International Crops Research Institute for the Semi-Arid Tropics, Sahelian Center, B.P. 12404, Niamey, Niger.

Menyonga, Joseph International coordinator, Semi-Arid Food Grains Research and Development Project, B.P. 1783, Ouagadougou, Upper Volta.

Morant, Philippe Agronomist, Institut de recherches agronomiques tropicales et des cultures vivrières, B.P. 32, Bobo-Dioulasso, Upper Volta.

Mulugetta Mekuria Head, Department of Socio-Economics and Farm Management Studies, Institute of Agricultural Research, P.O. Box 2003, Addis Ababa, Ethiopia.

Nygaard, David Head, Farming Systems Program, International Center for Agricultural Research in the Dry Areas, P.O. Box 5466, Aleppo, Syria.

Ohm, Herbert Agronomist, Farming Systems Unit (Purdue University)/Semi-Arid Food Grains Research and Development Project, B.P. 1783, Ouagadougou, Upper Volta.

Ouali, Firmin Economist, Institut voltaïque de recherche agronomique et zoologique, B.P. 596, Ouagadougou, Upper Volta.

Poats, Susan V. Anthropologist, Farming Systems Support Project, University of Florida, FSSP 3028 McCarty Hall, Gainesville, Florida 32611, USA.

Pocthier, Guy Agronomist, Institut de recherches agronomiques tropicales et des cultures vivrières, B.P. 5118, Dakar Fann, Senegal.

Poulain, Jean-François Agronomic engineer, Directeur pédagogique, Institut de recherches agronomiques tropicales et des cultures vivrières, Groupement d'études et de recherches pour le développement de l'agronomie tropicale, Domaine de Lavalette, Avenue du Val de Montfernand, B.P. 5098, 3433 Montpellier Cedex, France.

Renaud, Henri Agronomist, Institut de recherches agronomiques tropicales et des cultures vivrières/Autorité des aménagements des valées des Voltas, B.P. 633, Ouagadougou, Upper Volta.

Rhoades, Robert Anthropologist, Centro Internacional de la Papa, Apartado Aeréo 5969, Lima, Peru.

Rodriguez, Mario Maize agronomist, Semi-Arid Food Grains Research and Development Project/International Institute of Tropical Agriculture, B.P. 1783, Ouagadougou, Upper Volta.

Sall, Samba Agricultural economist, Institut sénégalais de recherches agricoles, B.P. 3120, Dakar, Senegal.

Sawadogo, Sibiri Agricultural economist, Farming Systems Unit (Purdue University)/Semi-Arid Food Grains Research and Development Project, B.P. 1783, Ouagadougou, Upper Volta.

Stoop, W.A. Agronomist, Royal Tropical Institute/International Crops Research Institute for the Semi-Arid Tropics, Verl. Slotlaan 26, 3707 Ch Zeist, Netherlands.

Singh, R.P. Economist, International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502324, Hyderabad, India.

Tagnan, Inoussa A. Semi-Arid Food Grains Research and Development Project, B.P. 1783, Ouagadougou, Upper Volta.

Tardieu, M. Regional coordinator, International Crops Research Institute for the Semi-Arid Tropics, Afrique de l'Ouest, B.P. 12404, Niamey, Niger.

Thiombiano, Taladidia Director, University of Ouagadougou, B.P. 7021, Ouagadougou, Upper Volta.

Prakah-Asante, K. Extension economist, West Africa Rice Development Association, P.M.B. 678, Freetown, Sierra Leone.

Tourte, René Chief, Division des systèmes agraires, Institut de recherches agronomiques tropicales et des cultures vivrières, Groupement d'études et recherches pour le développement de l'agronomie tropicale, B.P. 5035, 34032 Montpellier Cedex, France.

Vierich, Helga Principal social anthropologist, International Crops Research Institute for the Semi-Arid Tropics, B.P. 4881, Ouagadougou, Upper Volta.

Vordzorgbe, Seth Agroeconomist, Crops Research Institute, P.O. Box 52, Tamalé-Nyankpala, Ghana.

Wilson, R.T. Team leader/Senior animal scientist, Arid and Semi-arid Zones Programme, International Livestock Centre for Africa, B.P. 60, Bamako, Mali.

Zampalegre, Alassane Food and Agriculture Organization of the United Nations, Permanent Interstate Committee for Drought Control in the Sahel, Projet Lutte Integrée, B.P. 5573, Ouagadougou, Upper Volta.

Zerbo, Kassoum Research assistant, International Crops Research Institute for the Semi-Arid Tropics, B.P. 4881, Ouagadougou, Upper Volta.

Technical editor: Amy Chouinard
Assistant: Pierrette Legros